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Three takes on sustainability

Juha Honkatukia (ed.)

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Foreword

Finland has a long tradition of planning ahead in anticipation of looming changes. The topic of this book, sustainability and its implications for the economy is a case in point. Over the past two decades, countless studies have evaluated the likely consequences of ageing for economic growth and fiscal sustainability, and the policy responses available to alleviate them. More often than not these studies have used numerical methods, and to analyze the compound problems of ageing and structural change in the economy, the largest Finnish research institutes have devoted considerable resources to develop models capable of tackling these problems.

This book collects results from five recent studies, all utilizing numerical models, but focusing on slightly different aspects of the problems of ageing and sustainability. Together, they give a good overview of the joint capabilities of the models used in VATT, the Government Institute for Economic Research, the Bank of Finland, and the ETLA, The Research Institute of the Finnish Economy.

I would like to extend my warmest thanks to the contributors, Jukka Lassila and Tarmo Valkonen from ETLA, Juha Kilponen, Helvi Kinnunen, and Antti Ripatti from the Bank of Finland, and Juha Honkatukia and Saara Tamminen from VATT. I would also like to thank Jouko Vilmunen from the Bank of Finland for his support for the project, and Peter Dixon for taking the time to comment on the book and for putting it into a larger perspective in his introduction.

Helsinki 9 September, 2011

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Introduction

Peter B. Dixon[1]

This book describes numerical general equilibrium models created in three Finish organizations: the Government Institute for Economic Research (VATT); the Research Institute of the Finish Economy (ETLA); and the Bank of Finland (BOF). Each of the models is theoretically rigorous, contains detailed data, is solved by sophisticated computer programs and gives insights on major policy issues.

Many prominent economists are sceptical about the value of numerical general equilibrium modelling. Among them is my good friend Max Corden, Australia's most eminent economist. Often when I have managed to explain a difficult result to him, he responds with something along the lines: "That's pretty obvious. I could have worked that out with a diagram. You don't need a big complicated model for that." I have a few reactions to this. First I am quietly pleased: once the result is declared obvious, I know that I must have explained it well. Second, I don't doubt that Max could show the result with a diagram: no-one is more brilliant with diagrams than Max. But that doesn't mean that I, or even Max, could *work out* the result without the help of a formal model involving mathematics and computers. Models often reveal results that are not initially fully anticipated, but once revealed they can be understood and explained in a simple way. I will go further. A modelling result that cannot eventually be understood in a simple way is not worth having. Third, while Max's sharp theorizing can point in qualitative directions, for many problems this is not enough. Numerical general equilibrium modelling combining strong theory with real-world data provides the best chance of obtaining policy-relevant quantitative insights.

Econometricians are also sometimes sceptical about numerical general equilibrium modelling. They worry about relationships that are specified without statistical tests and about parameters that are calibrated by judgement rather than estimated from a database. But the problem is that if we confine ourselves to modelling that can be comprehensively supported by econometric techniques, then we narrow attention to issues that have historical precedents. While we should get as much as we can from historical databases, we must be prepared to build models that are capable of describing

[1] Sir John Monash Distinguished Professor, Centre of Policy Studies, Monash University, Australia.

> *"the behaviour of individuals in situations that have not been experienced before, such as in the case of longer lifetimes in the future" (Lassila, Valkonen and Alho in chapter 5 of this volume).*

With reduced reliance on the historical record, there is increased responsibility for modellers to explain and justify their results. What is the theory built into the model that leads to the projected effect *y* on variable *v* from shock *x*? Is this theory realistic? While it may not be possible to provide a formal econometric justification, are there other arguments or evidence that can be brought to bear? All of the modellers contributing to this book understand this responsibility. They all work hard to give common-sense and back-of-the-envelope explanations of their results.

The models presented here are well established with histories stretching back between 10 and 20 years. In each chapter, the model descriptions are accompanied by applications addressing policy challenges posed by an ageing population. This is a major issue in Finland, and one that is amenable to analysis via economic modelling. As Juha Honkatukia puts it in the first chapter:

> *"The challenge is two-fold: the ageing of the population increases age-related expenses, which should be met with rising tax revenues; but it also decreases labour supply, which tends to have the effect of lowering tax revenues. However, as taxation also has an effect on the incentives to work and to invest, solving this two-fold problem calls for a comprehensive re-evaluation of the structure of the whole tax system."*

All of the models trace out in different ways and with different emphases the interactions that Honkatukia describes.

VATT's model is a recursive dynamic, computable general equilibrium (CGE) model with a detailed industry dimension. A feature of the version of the model described in chapter 1 is the specification of consumption/leisure/saving choice by the household sector. This specification is critical for Honkatukia's application which is concerned with the welfare effects of different broad-based approaches to increasing government revenue: taxes on labour; taxes on capital; and taxes on consumption. Honkatukia sees increased taxation and a general strengthening of Finland's budgetary situation as a necessary prelude to building an effective policy response to population ageing. His simulations show a preference for taxes on consumption and capital, rather than taxes on labour. One way of thinking about this is that Finland already has high taxes on labour income, generating distortions in favour of leisure and against consumption and saving. This situation should not be exacerbated by further increases in labour taxes. In chapter 2, Honkatukia and Tamminen apply VATT's model to examine the effects of a specific proposal involving revenue-neutral cuts in income taxes and increases in value added and excise taxes. In view of the results in chapter 1 it is not surprising that they find that implementation of this proposal would increase overall welfare.

VATT's model used in chapter 1 treats the household sector as a single utility-maximizing entity. In the version of the model used in chapter 2, this is extended to 10 entities: households distinguished by income decile. As in most other CGE models, the households in VATT's model are static: they don't get older or die and they don't change their preferences (utility functions). Static households are a reasonable simplification for the VATT exercises reported in chapters 1 and 2 that are concerned with the short to medium term (going out no more than 15 years). However, for looking at long-term issues (going out say 50 years), we must allow explicitly for demographic change.

This is done in the ETLA and BOF models. In these models households evolve dynamically in accordance with an overlapping generations specification. In period t, households are classified into age cohorts. In period t+1, new households arrive and households from period t move on in age, change in composition or disappear. Households' preferences, including their preferences for work and leisure, change with age and composition as do their requirements for public expenditures on health and education.

In the ETLA analysis presented in chapter 5, Lassila, Valkonen and Alho use their overlapping generations model to calculate changes in the rates of different taxes that will be required out to 2060 to finance pensions, age-related health programs and other public expenditures under a variety of demographic projections. In chapter 3, Kilponen, Kinnunen and Ripatti use the BOF model to calculate the long-run effects

of changes in

life expectancy, average retirement age, fertility and pension payments

on

required contribution rates by workers and firms to pension funds, tax rates and a variety of macro variables.

In chapter 4, using another version of the BOF model, Kinnunen investigates the benefits of smoothing out the financing of pensions to avoid sharply elevated taxes or contribution rates during periods of rapid increase in pension liabilities. By avoiding spikes in tax and contribution rates, Kinnunen shows that work disincentive effects can be reduced, easing the burden of ageing.

In an environment of quantitative ignorance, ageing and associated financing problems seem frightening. But numerical modelling allows us to look at the situation in a calm quantitative fashion. It is true that ageing will mean either higher taxes and contribution rates or lower retirement benefit rates in the future. But for me, the quantitative results in this book are reassuring. For example, the

BOF results in chapter 3 indicate that no long-run ageing-related increases in taxes and contribution rates will be required if retirement pensions are reduced by 12 percentage points in relation to wages: from 55 per cent in a no ageing scenario to 43 per cent in the main ageing scenario. While no one would like to see such a cut in pensions, it should be remembered that the cut would be phased in over many years, and that with normal productivity and wage growth, pensions would still rise in real absolute terms.

Over the last 5 years I have made annual visits to Helsinki to work for a couple of weeks with Juha Honkatukia and his team at VATT. This has been a wonderful experience. I have seen first hand some of the excellent modelling research that has been performed in Finland. I am impressed that major policy institutions in Finland create, maintain and operate models of the type described in this book. The existence of these models is a testament to Finland's commitment to evidence-based economic policy.

1. The marginal cost of funds in Finland – an AGE evaluation

Juha Honkatukia

1.1 Introduction

Coping with the effects of an ageing population is among the foremost fiscal challenges in most industrialized countries. The challenge is two-fold: the ageing of the population increases age-related expenses, which should be met with rising tax revenues; but it also decreases labour supply, which tends to have the effect of lowering tax revenues. However, as taxation also has an effect on the incentives to work and to invest, solving this two-fold problem calls for a comprehensive re-evaluation of the structure of the whole tax system. Finland provides an interesting case for studying the pressures of ageing on public finances, as the large post-war baby-boomer generations are some years older than in most other countries, and the country thus already has to cope with the effects of ageing. The aim of this study is to compare the costs of different taxes thus providing analysis and assessments that can be used in the evaluation of tax reforms and the effects of public spending. We focus on the effects of labour and capital income taxes, and consumption taxes. In the current study, we model welfare with the help of a single representative consumer, abstracting for the moment from distributional issues.

We are using the VATTAGE model to compare the welfare effects of various tax increases designed to reduce Finland's budget deficits by using the concept of marginal cost of funds (MCF) for different taxes. VATTAGE is a MONASH-style model[2] of Finland documented in Honkatukia (2009). However, unlike the original MONASH model, VATTAGE has been extended to include leisure and savings choice in the specification of household behaviour, Dixon – Honkatukia. – Rimmer (2011). This extension is necessary for useful MCF calculations because the essence of these calculations is tax-induced distortions in choices between consumption, leisure and savings. The VATTAGE database relies on disaggregated data on the economy and allows us to distinguish between commodity taxes and taxes on different types of factor incomes as well as taxes on income transfers.

The aim of this chapter is to compare the costs of raising labour income, capital income taxes, or consumption taxes. In the current study, we model welfare with

[2] See Dixon and Rimmer (2002).

the help of a single representative consumer, abstracting for the moment from distributional issues. But even so, VATTAGE contains 82 industries and 91 commodities, and it is not easy to see the mechanisms at work from the full-scale model. To understand the results, we develop a simple model of the full-scale model, often called a **Back-of-the-envelope model.**

The main contribution of this paper is the development of a back-of-the-envelope (BOTE) equations – what is often referred to as a "model of a model" – to guide the explanation of MCF results generated from a full-scale, dynamic AGE model. We apply the equation in a discussion of the welfare effects of raising extra revenue by an increase in the rate of taxation on labour income.

The paper is organized as follows. Section 1.2 introduces the concept of MCF and discusses its application in CGE modelling. Section 1.3 overviews the VATTAGE model and introduces the extensions necessary to deal with labour-supply and saving-aspects of taxation. Section 1.4 develops the back-of-the-envelope equations for explaining MCF results from a full-scale dynamic CGE model. Section 1.5 applies the back-of-the-envelope equation. Concluding remarks are in section 1.6.

1.2 The concept of marginal cost of funds

The large literature on the excess burden of taxation suggests that the costs of raising revenue differ across tax instruments. But as argued by Creedy (2000), measures of excess burden are often concerned with comparisons of distortionary and non-distortionary (such as lump-sum) tax systems. In practice, however, changes in the tax system often involve collecting increased revenue with an existing, distorted tax system to finance increased public spending, for example.

In the analysis of optimal tax structure, the use of marginal cost of funds (MCF) based analysis has become popular. Similarly, applied general equilibrium modelling has gained strong momentum especially in analysing the dynamic effects of large policy changes. Dahlby (2008) points out that changes on just one tax rate can affect the collection of other tax types due to the common interdependence of the different tax types. Similarly, public spending in the form of a public projects or cash transfers also affects the revenue collected from taxes. The analyses of different types of policy changes with dynamic AGE models have also revealed that the effects of policies can be significantly different in the long run compared to the short run. In the long run all production factors are usually rather flexible, while in the short run particularly capital and nominal wages show rigidity. For these reasons we have selected to use a dynamic AGE model also for the analysis of marginal cost of funds.

The concept of marginal cost of funds, while related to excess burden considerations, is a broader concept that takes into account the type of effects that may arise when existing tax systems are modified, or when there are changes in public spending. Often, there are both types of effects.

MCF is usually defined as a money-metric measure of the loss of welfare resulting from the collection of extra revenue. Surprisingly, there seem to be several definitions for MCF. Here, we use the definition

$$\mathrm{MCF} = \left(\frac{-\mathrm{EV}}{\Delta \mathrm{R}} \right)$$

where EV is the equivalent variation resulting from the tax change and ΔR is the change in revenue.

The equivalent variation is often normalised by deducting the change in tax revenue (R) from EV in the denominator in the above equation, in order to account only for the changes in consumer's welfare consequential to the tax structure change, but not the increase in public spending itself (Chisario and Cicowiez, 2010). In this case, MCF can be either negative or positive. Here, we shall exogenise real government spending by assuming the extra revenue is used to pay back government debt. This does not isolate our measure completely from other government policies, since the price of public expenditure can be expected to differ under different tax regimes. Perhaps more importantly, the value of public transfers to the households and the other sectors of the economy is dependent on the changes in relative prices caused by the tax changes. But while this makes the definition of revenue targets difficult, it does not pose a problem fro the welfare measure, since the measure should take these effects into account.

An example of the application of the MCF concept in the context of AGE modelling to measuring the potential effects of a tax change is Go *et al.* (2005), which studies the effects of a value-added tax reform in South Africa. They compare the effects of an increase in VAT and income taxes on different households, finding marked differences in MCF across household types. Crucially, they assume no changes in factor supplies, government spending or the government's budget balance. Revenue is re-distributed in a lump-sum fashion, whence, as they point out, MCF is more of a measure of the overall inefficiency of the economy than that of just the tax system[3].

Working on Argentina, Chisario *et al.* (2007) study the impacts of the taxes under different regulatory systems. Using the alternative definition for MCF, they adopt similar assumptions to Go *et al.* and find MCFs ranging from 0.1. to

[3] $\mathrm{MCF} = -\mathrm{EV} / \Delta \mathrm{R}$ is sometimes also referred to as marginal welfare cost of taxation (Creedy, 2000).

0.5 for income taxes, -0.1 to 0.13 for capital income taxes, and 0.127 to 0.206 for value added taxes.

In the AGE studies cited above, the determination of labour supply and saving is not at the centre of the analysis. This is somewhat surprising, because the theoretical literature on MCF considers the effects on labour-leisure choice extensively. As Dahlby (2009) shows, labour markets affect the costs of taxation in several ways. First, the effects of income taxes depend on the supply and demand elasticities for labour. They also depend on labour/capital ratios, as part of the burden of labour taxes is actually borne by capital, depending on whether the price of labour inputs is affected. The latter, in turn, depends on the labour market specification, that is, whether wages are competitive, or whether there are wage rigidities.

The empirical literature on MCF also suggests that labour supply matters. A study by Kleven and Kreiner (2006) estimates MCFs from income taxes for several European countries, finding MCFs ranging from 0 to 0.32 for a proportional increase in income taxes, when they consider labour supply elasticities for the intensive margin (that is, for hours worked). Tax reforms have been also studied econometrically in several other European countries, but to our knowledge, the concept has not been introduced in recent European AGE applications.

Our study for Finland is similar in spirit to the South Africa and Argentina studies in the sense that it uses an AGE model for evaluating the costs of different tax regimes. However, the calculation of the marginal cost of funds with a dynamic, applied general equilibrium models is still not common, while the use of static, applied GE models for MCF calculations was started already a long time ago (Ballard *et al* ,1985). More importantly, where we differ from the earlier studies is that we introduce endogenous labour/leisure choice and endogenous saving decisions, allowing us to consider effects that are excluded from the earlier analyses by the model formulation, and bringing our model closer to the theoretical literature on MCF.

1.3 An outline of VATTAGE

VATTAGE is a dynamic, applied general equilibrium (AGE) model of the Finnish economy. It can be used to study the effects of a wide range of economic policies. The VATTAGE database contains detailed information on commodity and income taxes as well as on the public sectors and thus covers most policy instruments available to the government.

VATTAGE is based on the MONASH-model developed at the Centre of Policy Studies in Monash University. MONASH-type models are used in countries ranging from China and South Africa to the United States (Dixon and Rimmer,

2002) In Europe, models based on MONASH have been developed for Denmark, Finland, and the Netherlands.

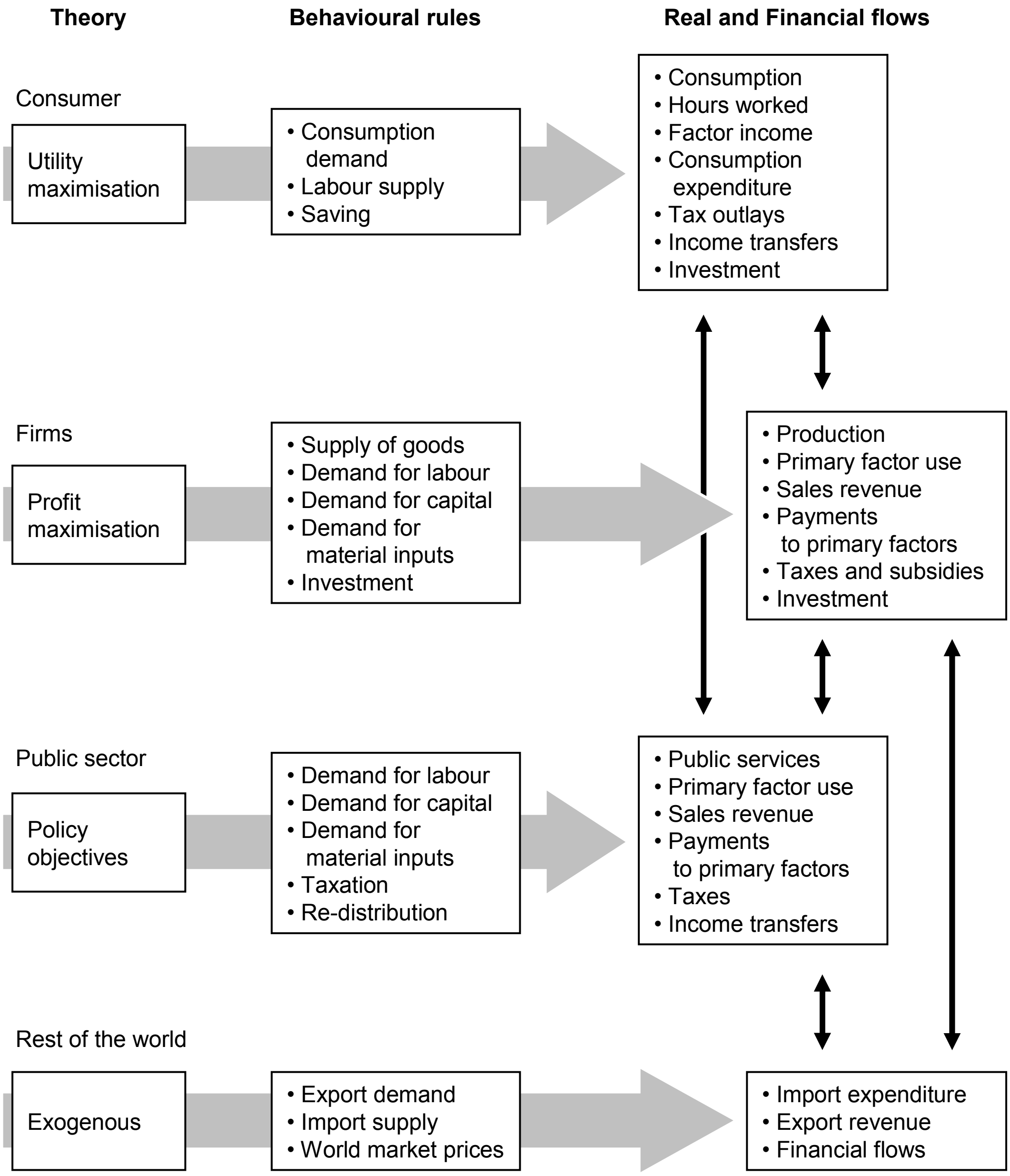
In VATTAGE, there are three types of inter-temporal links connecting the consecutive periods in the model: (1) accumulation of fixed capital; (2) accumulation of financial claims; and (3) lagged adjustment mechanisms, notably in the labour markets. Different fiscal rules for the balancing of the public sector budgets can also be specified.

The VATTAGE database collects information on the structure of the Finnish economy derived from the national accounts, arranged in a presentation reflecting the theoretical structure of the model. The database also contains the behavioral parameters that are used to operationalise the behavioral assumptions made in the model. National accounts collect data on the use goods and services by industry and by product, but it also contains accounts for production as well as financial positions by institutional sector. (Eurostat 1997, 1.) The institutional sectors are viewed as independent decision-makers (Statistics Finland 2000, 11.), and it is the behaviour of these decision-makers that the model parameters and coefficients derived from the data describe and control.

A large part of the database consists of input-output data that captures the structure of demand for intermediate goods and primary factors by industries, the final good consumption by consumers, the public sector, and the rest of the world. However, input-output data does not contain data on income flows, which must be obtained from other sources in national accounts.

Furthermore, the data base also presents the transactions in the economy taking place between the institutional sectors of the economy. In the database, transactions take place both between domestic sectors, and between domestic and foreign sectors. The domestic sectors are divided into three domestic subcategories whereas the foreign sectors represent foreign countries and multinational and international organizations. These institutional sectors are mutually exclusive and their role in the economy can thus be unequivocally presented. For example, export demand is final demand for domestic goods and services by the foreign sectors.

Figure 1 The structure of VATTAGE



VATTAGE models production with conventional, nested production functions. The idea behind industrial classification is to group activities whose production processes or the products they make are similar. However, VATTAGE also allows for multi-production of commodities. The VATTAGE database uses the national industrial classification TOL 2002, basing on NACE 2002 and ISIC Rev. 3.1, to classify industries, and the CPA-classification to group products. The detailed data on commodities allows us to study the production of goods almost at a process level.

In VATTAGE, households are assumed to be the recipients of factor incomes. They also possess assets and liabilities abroad and domestically, which implies that a part of domestic incomes will be channeled abroad. To study MCF, we have extended the basic VATTAGE model by allowing households to make endogenous choices between leisure (or equivalently labour-supply), consumption of commodities and savings. To do this we have adopted the simplest approach, treating leisure and saving (deferred consumption) as two more "commodities" in household choice. The household's problem has been amended to allow for the treatment of full income, that is, income inclusive of the value of leisure.

VATTAGE allows for different treatments of the labour markets. The labour market equations relate population and population of working age, and define unemployment rates in terms of demand and supply of labour. In dynamic simulations, labour supply is typically taken as exogenous, while wages adjust only gradually and unemployment is determined endogenously.

1.4 A Back-of-the-envelope model for understanding VATTAGE results for the marginal cost of funds

1.4.1 Production

We assume that the **Back-of-the-envelope** (hereafter BOTE) economy produces one good with a production function given by

$$Y = F(K, N, M). \tag{1}$$

where

Y is output; and

K, N and M are inputs of capital, labour and imports.

In the BOTE model we assume that all imports are used as intermediate inputs. This is a convenient assumption and not limiting.

Under cost-minimizing assumptions, K, N and M satisfy

$$P_Y * F_K = P_Q . \tag{2}$$

$$P_Y * F_N = P_W . \tag{3}$$

$$P_Y * F_M = P_M * T_M . \tag{4}$$

where

F_K, F_N and F_M are the marginal products of capital, labour and imports (derivatives of F);
P_Y is the price of a unit of output;
P_Q is the pre-tax rental per unit of capital ;
P_M is the c.i.f. price of a unit of imports; and
T_M is the power of the tariff on imports (one plus the rate).

Apart from the tariff on imports, we assume that there are no indirect taxes on inputs to production. This is realistic for Finland.

Totally differentiating (1) and substituting from (2) to (4) gives:

$$dY = \frac{P_Q}{P_Y} * dK + \frac{P_W}{P_Y} * dN + \frac{P_M * T_M}{P_Y} * dM \tag{5}$$

where

dY, dK, dN and dM are the policy-induced deviations in output, capital, employment and imports.

1.4.2 Household behaviour in the Back-of-the-envelope model

We assume that in each year the household sector chooses its quantities of consumption (C), leisure (L) and reserved consumption (R) to maximize a utility function. By reserved consumption we mean the number of units of consumption that the household sector expects to be able to finance in the future through this year's saving. In VATTAGE the utility function is additive (Stone-Geary). Reflecting this, for the BOTE model we assume that households maximize:

$$U_C(C) + U_L(L) + U_R(R) \tag{6}$$

subject to

$$P_C * C + P_R * R = Z + \left(\frac{P_W}{T_W} \right) * N \tag{7}$$

and

$$L = H - B - N \tag{8}$$

where

H is total hours available for work;
B is hours in involuntary unemployment;
N is hours of employment;
P_W is the pre-tax wage rate;
T_W is the power of the tax on labour income;
Z is household non-labour income;
P_R is the price of a unit of reserved consumption (to be discussed in subsection 1.2.6);
P_C is the price of a unit of consumption.

In (8), we assume that involuntary unemployment is not leisure and consequently gives no utility.

The price of consumption is given by

$$P_C = P_Y * T_C \tag{9}$$

where

T_C is the power of the tax on consumption.

The first order conditions from problem (6) to (9) are:

$$U_C^{/}(C) = \lambda * P_Y * T_C \tag{10}$$

$$U_L^{/}(L) = \lambda * P_W / T_W \tag{11}$$

$$U_R^{/}(R) = \lambda * P_R \tag{12}$$

where

the superscript prime denotes derivative; and
λ is the Lagrangian multiplier which can be interpreted as the increase in utility that the household would derive from an extra dollar of income (a unit increase in Z).

In specifying the demand functions arising from (10) – (11), we assume that the relevant price for leisure is the nominal after tax wage rate. For saving, the choice of a price level is more complicated and is treated in section (6). To implement the new formulation, we use demand elasticities with respect to full income for leisure of 0.3 – which implies a labour-supply elasticity of roughly 0.1 on the average - and of 0.5 for savings.

As is apparent from the demand equations, consumption of commodities, leisure and saving are now interrelated, whereas in the old model formulation, labour market specification drives the reaction of employment to taxes, and saving is affected by taxation only to the extent household disposable income changes. It is not a priori clear how large an effect these differences will make and thus the experiments below also illustrate the differences in model specifications.

The differences between the new and old model formulation can be summarized by comparing the effects of changes in income and prices on demands in the old and new expenditure functions. From Table 1, it can be seen that the new formulation introduces several new channels for taxes to have an effect. In the table, the negative cross-price effect calls for a comment. The effect is apparent from equation (4), whence it can be seen to reflect the effect of subsistence demands for commodities, leisure, and saving on the demand for other goods. Its magnitude depends on the consumption shares of the other goods as well as the levels of subsistence demands.

Table 1 The expected effects of income and prices on demands

Model	Demands for	Disposable income	CPI	RW	PCAP
OLD	Consumption	+	-		
NEW	Consumption	+	-	-	-
	Leisure	+	-	-	-
	Saving	+	-	-	-

1.4.3 Economic welfare in the Back-of-the-envelope model

We assume that households in year t derive welfare from their consumption and leisure, but not from their reserved consumption which will give them welfare in some future year. Under this assumption, welfare (W) in any year is given by

$$W = U_C(C) + U_L(L) \tag{13}$$

and the deviation in welfare in the year caused by implementation of a policy is calculated as

$$d\,W = U_C^{/} * dC + U_L^{/} * dL \tag{14}$$

where

dC and dL are the policy-induced deviations in consumption and leisure.

Substituting from (10) and (11) into (14) gives

$$\omega = P_C * dC + \frac{P_W}{T_W} * dL \tag{15}$$

where

$$\omega = \frac{dW}{\lambda} \quad . \tag{16}$$

ω is the monetary gift that would generate the same change in household welfare as that generated by the policy.

1.4.4 National accounts identity and contribution of accumulated savings in the Back-of-the-envelope model

We define national savings (S) by

$$S = Y - \frac{P_M}{P_Y} * M - (C + G) - V \tag{17}$$

where

G is public consumption; and

V is net payments of interest and dividends to foreigners.

Equation (17) is expressed in real terms. To understand it we can think of output Y as a number of bags of wheat. Similarly, C, G and V are numbers of bags of wheat that are: consumed by households; consumed by the government; and paid to foreign asset holders. $(P_M/P_Y)*M$ is the number of bags of wheat owed to foreigners as payment for imports. S is then the increase in the nation's assets (i.e. saving) calculated in bags of wheat.
In deviation form (17) can be written as

$$dS = dY - d\left(\frac{P_M}{P_Y}\right) * M - \frac{P_M}{P_Y} * dM - dC - dG - dV \quad . \tag{18}$$

Then using (5) in (18) yields, after rearrangement

$$dS = \frac{P_W}{P_Y} * dN + \frac{P_M}{P_Y} * (T_M - 1) * dM - d\left(\frac{P_M}{P_Y}\right) * M - dC - dG + \left(\frac{P_Q}{P_Y} * dK - dV\right) \tag{19}$$

The last term in (19) is the contribution to national income in year t of the policy-induced change in capital less the policy-induced increase in net dividends and interest payments to foreigners. If the policy is implemented in year 1 then this contribution in year t arises from the accumulation (dA) of policy-induced increases in savings between years 1 and t-1. Under the simplifying assumption that investments, whether physical or financial, earn a constant exogenously given rate of return of ρ, we can write the last term in (19) as

$$\left(\frac{P_Q}{P_Y} * dK - dV\right) = \rho * dA \tag{20}$$

where

dA for year t is given by

$$dA = \sum_{\tau=1}^{t-1} dS_\tau \ , \tag{21}$$

or alternatively

$$dA_\tau = dA_{\tau-1} + dS_{\tau-1} \qquad \text{for } \tau = 1, 2, \ldots, t \tag{22}$$

and

$$dA_0 = dS_0 = 0 \, . \tag{23}$$

1.4.5 The effects of policies on welfare: an interpretable back of the envelope equation

Rearranging (19) and inserting (20) gives

$$dC = \frac{P_W}{P_Y} * dN + \frac{P_M}{P_Y} * (T_M - 1) * dM - d\left(\frac{P_M}{P_Y}\right) * M - dG + (\rho * dA - dS) \tag{24}$$

From (8), with dH = 0, we obtain

$$dL = -dB - dN \quad . \tag{25}$$

Now substituting from (24), (25) and (9) into (15) gives

$$\begin{aligned}
\omega = \quad & 0.01 * \left(\frac{P_W * N}{T_W}\right) * (T_W * T_C - 1) * n && \text{employment/leisure effect} \\
& + 0.01 * (P_M * M) * T_C * (T_M - 1) * m && \text{import effect} \\
& - 0.01 * (P_M * M) * T_C * (p_M - p_Y) && \text{terms-of-trade effect} \\
& - 0.01 * \left(\frac{P_W * B}{T_W}\right) * b && \text{involuntary unemployment effect} \\
& + P_Y * T_C * (\rho * dA - dS) && \text{inter-temporal trade-off effect} \\
& - 0.01 * P_Y * T_C * G * g && \text{government consumption effect}
\end{aligned} \tag{26}$$

where

> n, m, p_M, p_Y, b and g are policy-induced percentage deviations in the variables denoted by the corresponding upper-case symbols.

Equation (26) is a BOTE decomposition of the effect on welfare in year t of policy changes implemented in years 1 to t.

Employment leisure effect

The first term on the right hand side of (26) shows the welfare effect of policy-induced changes in employment. To understand this term we should think of unemployment, B, and total hours, H, as fixed: the effects on welfare of movements in B are calculated in the fourth term on the right hand side of (26) and, in the derivation of (26), H was explicitly held constant (that is not affected by the policy). With B and H fixed, increases in employment, N, are at the cost of leisure, L. However, because of tax effects an extra hour of work generates more welfare than an extra hour of leisure. Specifically, an hour of work generates P_W/P_Y extra units of output, see (3). The value to households of this extra output is P_C*P_W/P_Y, that is T_C*P_W. The value of an extra hour of leisure to households is P_W/T_W. Thus the net effect on welfare of an extra hour of labour with a corresponding loss of one hour of leisure is $T_C*P_W - P_W/T_W$. From here we can quickly arrive at the employment/leisure effect given in (26).

Import effect

The second term on the right hand side of (26) shows the welfare effect of policy-induced changes in imports. To understand this term we should start by thinking of K and N as constant: the effects of movements in these variables are accounted for in the first and fifth terms. With K and N constant, an extra unit of imports generates an increase in output of P_M*T_M/P_Y units, see (4). But not all of this increase in output can be consumed. We should think of S, G, V and P_M/P_Y as being constant, with the effects of their movements accounted for in other terms. With these variables constant, (18) implies that a unit increase in imports must be financed by a payment to foreigners of P_M/P_Y units of output. Thus, a unit increase in imports allows an increase in consumption of $P_M*T_M/P_Y - P_M/P_Y$ units. To find the value of this to consumers we multiply through by P_C. This leads to the second term on the right hand side of (26).

Terms-of-trade effect

If the terms of trade decreases by 1 per cent, that is if the c.i.f. price of imports increases by 1 per cent relative to the price of domestic output ($p_M – p_Y = 1$), then foreigners will need to receive 1 per cent more units of domestic output to pay them for any given level of imports. With S, K, N and M held constant, this means that payments to foreigners must increase by $0.01*P_M*M/P_Y$ units of output, with a corresponding reduction in consumption. The value of this reduction in consumption can be found by multiplying through by P_C, leading to the third term on the right hand side of (26).

Involuntary unemployment effect

With H and N held constant an increase of one hour in involuntary unemployment generates a reduction in leisure of one hour. The value of an hour's leisure to households is P_W/T_W. Thus, the effect on welfare of a *b* per cent increase in unemployment is given by the fourth term on the right hand side of (26).

Inter-temporal trade-off effect

The policy-induced deviation in accumulated saving up to year t allows consumption to increase by ρ*dA units of output in year t whereas extra saving in year t requires a reduction in consumption of dS units in year t. On translating these two effects (one positive and one negative) into monetary units by multiplying through by P_C, we obtain the inter-temporal trade-off effect which is the fifth term on the right hand side of (26).

In a simulation in which there is a sustained policy-induced increase in saving, the inter-temporal trade-off effect is negative in early years but positive in later years.

Government consumption effect

In deriving (26) we assumed that government expenditure does not generate welfare. Under this assumption an increase in government expenditure of one unit, with a corresponding reduction in consumption of one unit, generates a welfare loss with a monetary value of P_C. This leads to the last term on the right hand side of (26). It would be a relatively simple matter to modify VATTAGE and the BOTE model to allow public consumption to be welfare generating.

1.4.6 The price P_R of reserved consumption

When households in year t save a unit of output worth PY dollars, we assume that they expect this to be transformed into a unit of capital. [For simplicity we assume that a unit of capital is created from one unit of output.] They expect the unit of capital to generate extra units of output in the future in line with the current marginal product of capital (PQ/PY). They take into account the power of the tax on capital income (TK) and recognize that their entitlement to the extra output is limited to PQ/(PY*TK). They assume that the extra output that they are entitled to is translated into extra units of consumption (an increase in reserved consumption R) by multiplying by the ratio of output prices to consumption prices (PY/PC). Putting all of this together, we have

$$P_Y \rightarrow \left(\frac{P_Q}{P_Y * T_K}\right) * \left(\frac{P_Y}{P_C}\right) , \tag{27}$$

that is, saving of PY in year t yields a quantity of reserved consumption that is proportional to the expression on the right hand side of (27). Where the factor of proportionality is α, (27) gives us the price of a unit of reserved consumption as

$$P_R = \left(\frac{1}{\alpha}\right) * \left(\frac{P_Y}{\left[P_Q / \left(P_Y * T_K\right)\right] * \left(1 / T_C\right)}\right) , \tag{28}$$

that is,

$$P_R = \left(\frac{1}{\alpha}\right) * \left(\frac{P_Y * T_C * T_K}{\left(P_Q / P_Y\right)}\right) , \tag{29}$$

The role of PR in VATTAGE is clear from section 1.4.2. If PR increases relative to the prices of consumption (PC) and leisure (PW/TW), then the household sector allocates more of its full income to consumption and leisure and less to reserved consumption, that is less to saving. Thus, under (29) saving is inhibited by increases in taxes on capital income and stimulated by increases in the marginal product of capital (PQ/PY). An increase in taxes on consumption (TC) generates an increase in PR but it also generates an increase in PC. Thus it is not clear a priori how an increase in consumption taxes affects the savings/consumption ratio. However, it is clear that an increase in consumption taxes will increase leisure relative to both savings and consumption.

1.4.7 A Back-of-the-envelope model for the effects of taxes on the macroeconomy

In a dynamic setting, it is not immediately obvious what is meant with a balanced budget. Fixing a deficit will affect the accumulation of debt by the government; but assuming lump-sum redistribution of revenue involves more of a redistributive tax change analysis than an evaluation of the costs of specific taxes. Here, we assume that the extra revenue is spent exhaustively by the government. To keep the three tax scenarios as comparable as possible, we assume the revenue is used to cut the government deficit, or, to increase government saving. This implies that the revenue in the first hand is used to paying back government debt. However, since any of the taxes will affect the ability of other taxes to raise revenue, we do not specify the target in terms of the deficit itself, since this might imply that real government spending differs between the three scenarios. Furthermore, if the aim of the policy is to increase national saving, there is a real possibility of government saving crowding out private saving, resulting, again, in differences between the scenarios. We attempt to solve this problem by specifying the revenue target in terms of national saving. This implies the same national saving in each of the scenarios, but government deficits may vary between the scenarios.

The experiments considered in this section involve the collection of revenue by raising either wage income taxes, capital income taxes, or all commodity taxes paid by the consumer. For illustrative purposes, we assume an extra 1 billion euros as the revenue target, to be implemented 2010. The tax bases for the three taxes are unequal, with wage income taxes estimated to raise about 14.3 billion in our baseline for 2009, capital taxes about 12.9 billion, and commodity taxes about 23.4 billion euros. The choice of magnitude for the experiment will affect the results, since MCF depends on the scale of the change. This can easily be seen with the help of our BOTE model for production and the consumer's choice.

Abstracting from intermediate inputs, the value marginal product of labour can be expressed as

$$W = \frac{P_g}{T_g} * A * f\left(\frac{K}{L}\right), \tag{30}$$

where

W is the nominal before-tax wage rate;

P_g is the price deflator for GDP;

T_g is the power of the indirect tax rate applying to production in Finland (can also include taxes in inputs, but in this stylized model we will ignore non-primary-factor inputs); and

$A * f(K/L)$ is the marginal product of labour derived from the constant-returns-to-scale production function, Y= A*F(K,L).

Thus

$$\frac{W}{P_c} = \frac{P_g}{T_g} * A * f\left(\frac{K}{L}\right) * \frac{1}{P_c}, \tag{31}$$

where

W is the nominal pre-tax wage rate;

T_w is the power of the tax on labour income; and

P_c is the price deflator for consumption.

Consumer prices are linked to the price of GDP by $P_c = P_g * T_c$, where T_c is the power of consumption taxes (1+ad valorem equivalent rate).

With a CES production function, the percentage change in f(K/L), when K is held constant, is given by:

$$\%\Delta f = -\frac{S_k}{\sigma} l \,, \tag{32}$$

where l is the percentage change in employment, S_k is the capital share in returns to primary factors and σ is the elasticity of substitution between capital and labour. The consumer's utility maximization problem implies that labour supply is linked to the demand for leisure, with the price of leisure being given by the after-tax real wage, and of full income, which in turn is also affected by real wages. Thus we have a link between labour supply and real wages, which is of the form

$$l = \varepsilon * (w - p_c - t_w) \,, \tag{33}$$

where ε is the elasticity of labour supply with respect to after-tax real wages, and w, p_c,and t_w are the percentage changes in the nominal wage level, consumer prices and the power of wage taxes, respectively. The elasticity ε depends on the share of labour income, as well as the elasticity of substitution between leisure and other consumption. We calibrate the latter to imply a supply elasticity of 0.1, following the estimates for several EU countries obtained in Kleven *et al*. (2006).

Since we assume only one good, we have

Substituting (33) and (32) in (31), we have, for pre-tax real wages,

$$w - p_c = C_1 * \left(t_g + t_c - a - C_2 * t_w\right) \,, \tag{34}$$

where

$$C_1 = \frac{-1}{\left(1 + \frac{S_k * \varepsilon}{\sigma}\right)} \,, \tag{35}$$

and

$$C_2 = \frac{S_k * \varepsilon}{\sigma} \,, \tag{36}$$

and where σ is the elasticity of substitution between capital and labour in (1) and t_c the percentage change in the power of consumption taxes. Under our specification, with a capital share from value added at around 0.35, the value of C_1 is reoughly -.84, whereas C_2 is roughly 0.18.

From (34) it is clear that the base for different taxes is relevant for the behavior of labour supply and thus for the economy as a whole. If the tax base is large – as in the case of t_g, the relative effect on real wages will be smaller.

Finally, the production function in the BOTE model can be used to get a rough estimate of the effects of the taxes on GDP. The change in GDP is given by

$$y = S_k l + S_k k + a. \tag{37}$$

and the demand for labour is implied by the production function, being given by

$$l = -\frac{\sigma}{S_L} * (w - p). \tag{38}$$

Once the behavior of real wages is clear from (34), we can get employment effects from (38), which, recognizing that capital stock is fixed in the short run, implies the effects on GDP.

We can now study the effects of our three experiments with the help of the BOTEs for production and welfare.

1.5 The effects of increases labour, capital, and consumption taxes

We compare the costs of raising labour income, capital income, or consumption taxes in terms of their effects on welfare. We assume that the revenue target is a billion euros, to be achieved over four years. This could be modelled as a target on government deficit as a fall of 250 million Euros a year.

1.5.1 The macroeconomic effects of labour, capital, and consumption taxes

Table 2 below gives our BOTE calculations for the effects of labour taxes on real wages, employment, and GDP. From the table, it can be seen that the collection of 250 million in real revenue via increased taxes on labour income imply a 0,54 per cent increase in the power of labour taxes. The power of taxes over GDP is also affected, since t_g will capture the increase in labour taxes relative to value added. The power of consumption taxes is affected for compositional reasons: the decrease in real wages implied by both the BOTE and the simulation results will feed into the relative prices of consumption goods, changing the composition of the consumption basket slightly, and thus affecting the revenue from consumption taxes, from which we calculate the overall power of consumption taxes.

The BOTE overestimates the magnitude of real wage changes compared to the actual simulation under the parameter values used here. The BOTE also overlooks the effect of changes in intermediate and product taxes on GDP, which in Finland is fairly high. In the actual simulation, a fall in indirect tax revenues is marked and contributes to the overall fall in GDP, as can be seen from Figure 2. Accordingly, the BOTE overestimates the effect on employment of real wages compared to the full simulation. The reason for the positive contribution of technology in the simulation results is only apparent when we consider the structural effects of taxes falling on the consumer. They tend to favour export industries, where the productivity of labour is higher than in the domestic-market industries, partly because the fall in real wages increases competitiveness by lowering the terms of trade, partly because the fall in domestic consumption directly frees up resources for the export industries. The latter effect is evident also with the other taxes, but it is most marked under labour taxes. This effect is apparent from Figure 3 which depicts changes in the expenditure side GDP, showing exports to benefit but consumption to fall. The terms of trade effect is largely behind a fall in imports, which shows up as a positive contribution to GDP.

Table 2 The effects of taxes on labour income

	2010	2011	2012	2013	2014	2015
Tg	0.000	0.107	0.121	0.110	0.107	0.013
Tl	0.000	0.540	0.559	0.493	0.462	0.000
Tc	0.000	0.051	0.016	0.023	0.015	-0.017
Technological change	0.000	-0.054	-0.042	-0.045	-0.041	0.000
Pre-tax real wage (BOTE)	0.000	-0.005	-0.065	-0.074	-0.066	0.003
Pre-tax real wage (SIM)	0.000	0.001	-0.009	-0.007	-0.016	-0.026
Post-tax real wage (SIM)	0.000	-0.538	-0.565	-0.495	-0.474	-0.026
Employment (BOTE)	0.000	0.000	0.003	0.002	0.005	0.008
Employment (SIM)	0.000	-0.004	-0.020	-0.007	-0.008	0.001
Real GDP (BOTE)	0.000	-0.054	-0.041	-0.044	-0.038	0.005
Real GDP (SIM)	0.000	-0.056	-0.055	-0.049	-0.046	0.000

Figure 2 *Contributions to income-side GDP under labour taxes*

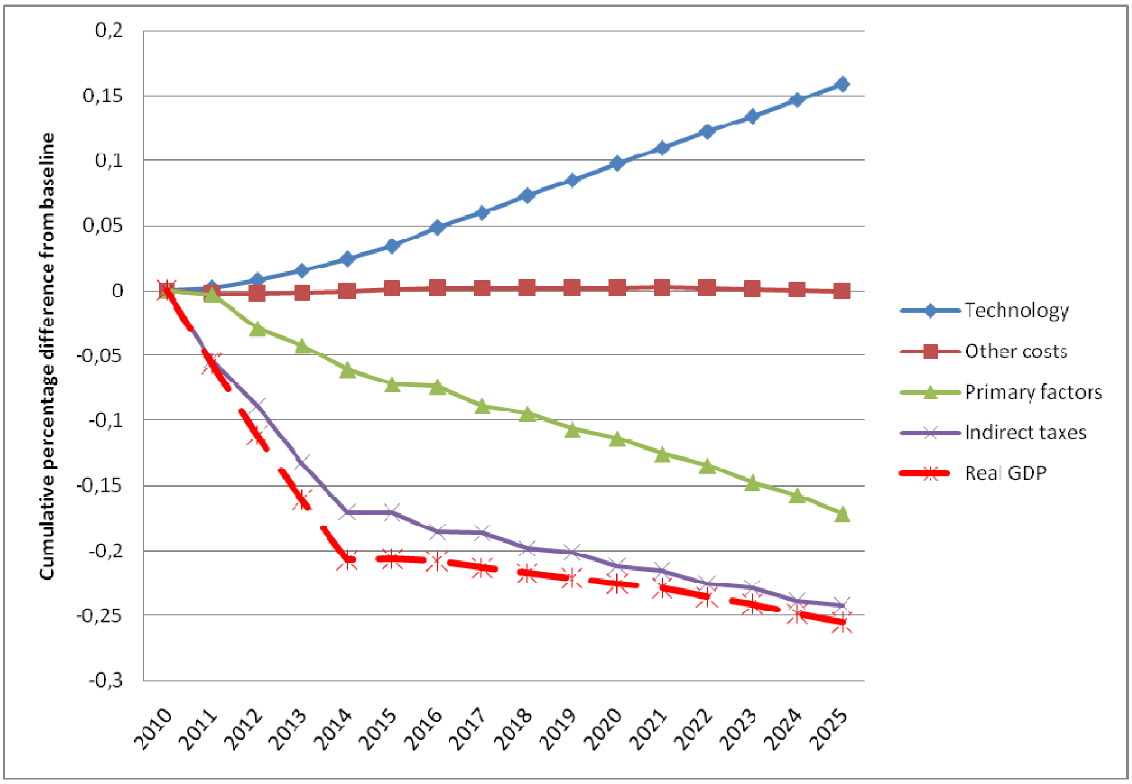


Figure 3 *Contributions to expenditure-side GDP under labour taxes*

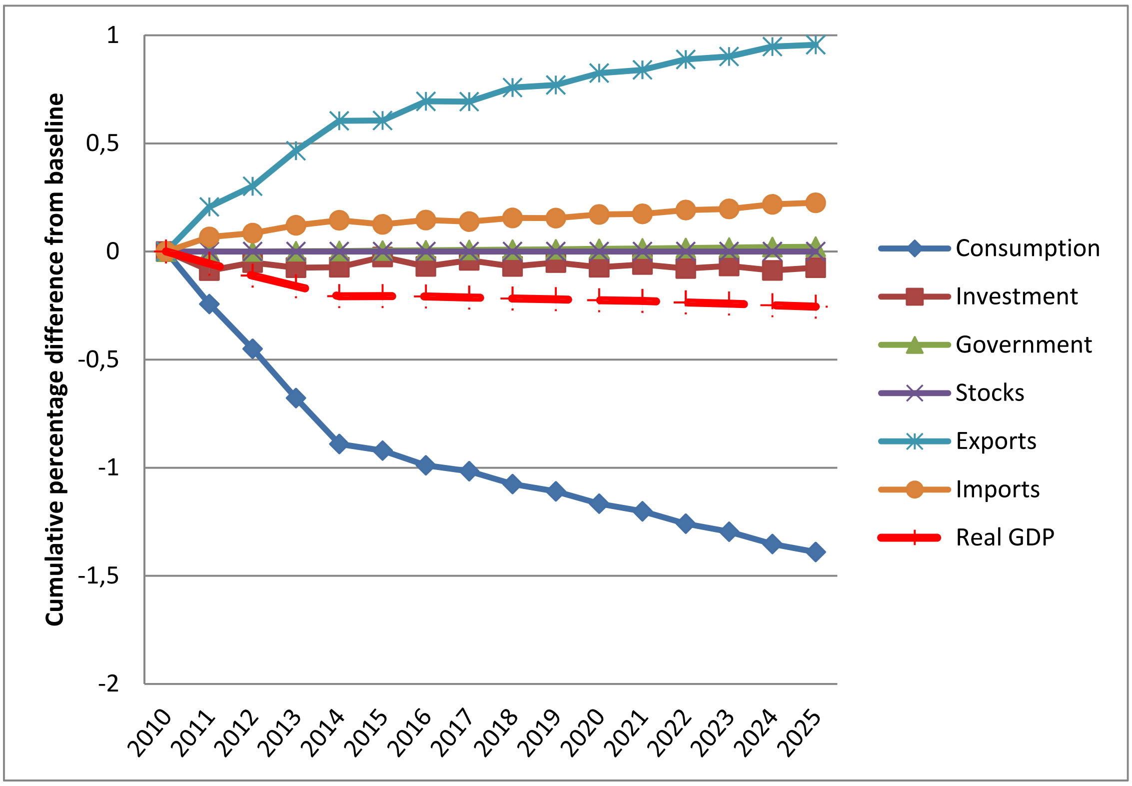


Table 3 shows our BOTE for capital taxes. The increase in capital taxes is captured by t_g but again, also consumption taxes are affected for the compositional reasons mentioned earlier. Compared to labour taxes, the increase in both of these powers is smaller, but since there is no compensating change in labour taxes, the effect on real wages is actually larger than with labour taxes. Thus there is an increase in labour demand, and again, the export industries benefit compared to the labour tax case. However, the rise in capital taxes will tend to raise the pre-tax rate of return on investment, which has a negative impact on investment. This can be seen as a negative contribution of investment to expenditure-side GDP in the short run in Figure 5, and in the long run as a fall in the contribution of primary factors to GDP in Figure 4.

Table 3 The effect of taxes on capital income

	2010	2011	2012	2013	2014	2015
Tg	0.000	0.050	0.065	0.059	0.055	0.005
Tl	0.000	0.000	0.000	0.000	0.000	0.000
Tc	0.000	0.052	0.014	0.020	0.014	-0.027
Technological change	0.000	-0.054	-0.049	-0.055	-0.055	-0.009
Pre-tax real wage (BOTE)	0.000	-0.132	-0.108	-0.113	-0.105	0.011
Pre-tax real wage (SIM)	0.000	-0.103	-0.129	-0.106	-0.114	-0.024
Post-tax real wage (SIM)	0.000	-0.104	-0.129	-0.106	-0.114	-0.024
Employment (BOTE)	0.000	0.030	0.038	0.031	0.033	0.007
Employment (SIM)	0.000	0.045	0.030	0.038	0.035	-0.006
Real GDP (BOTE)	0.000	-0.035	-0.025	-0.035	-0.034	-0.005
Real GDP (SIM)	0.000	-0.025	-0.030	-0.030	-0.033	-0.013

Figure 4 *Contributions to income-side GDP under capital taxes*

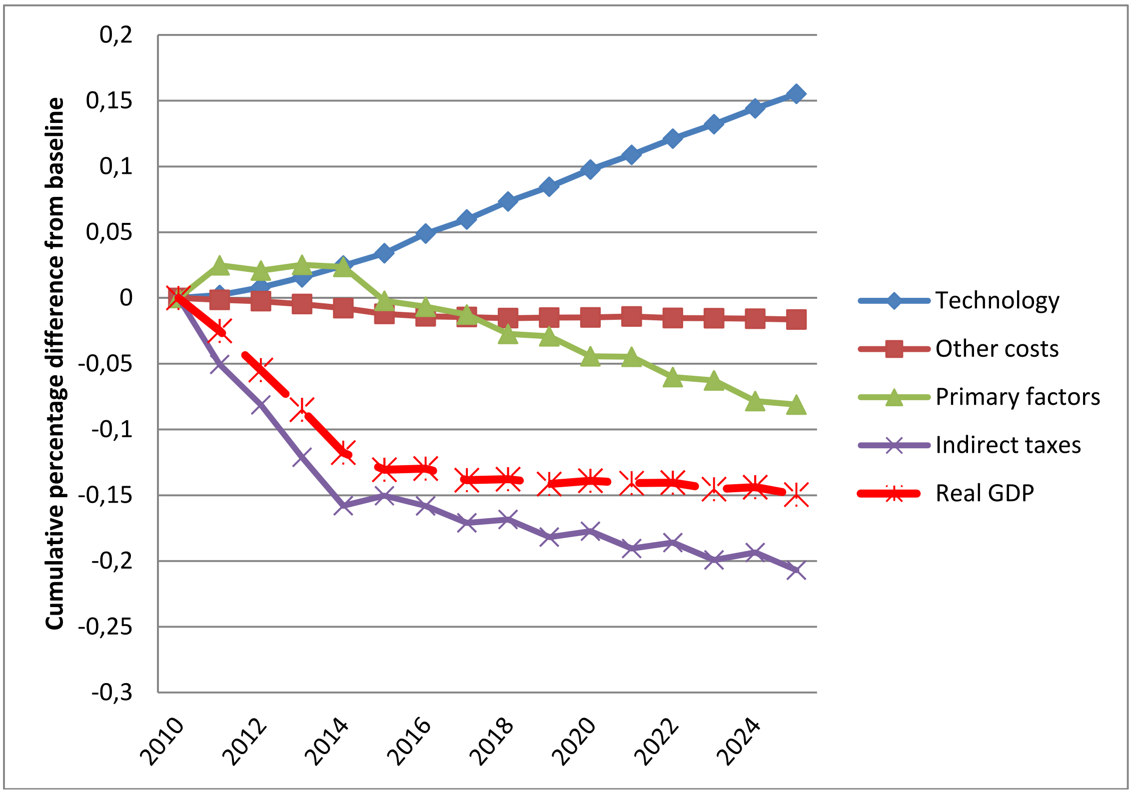
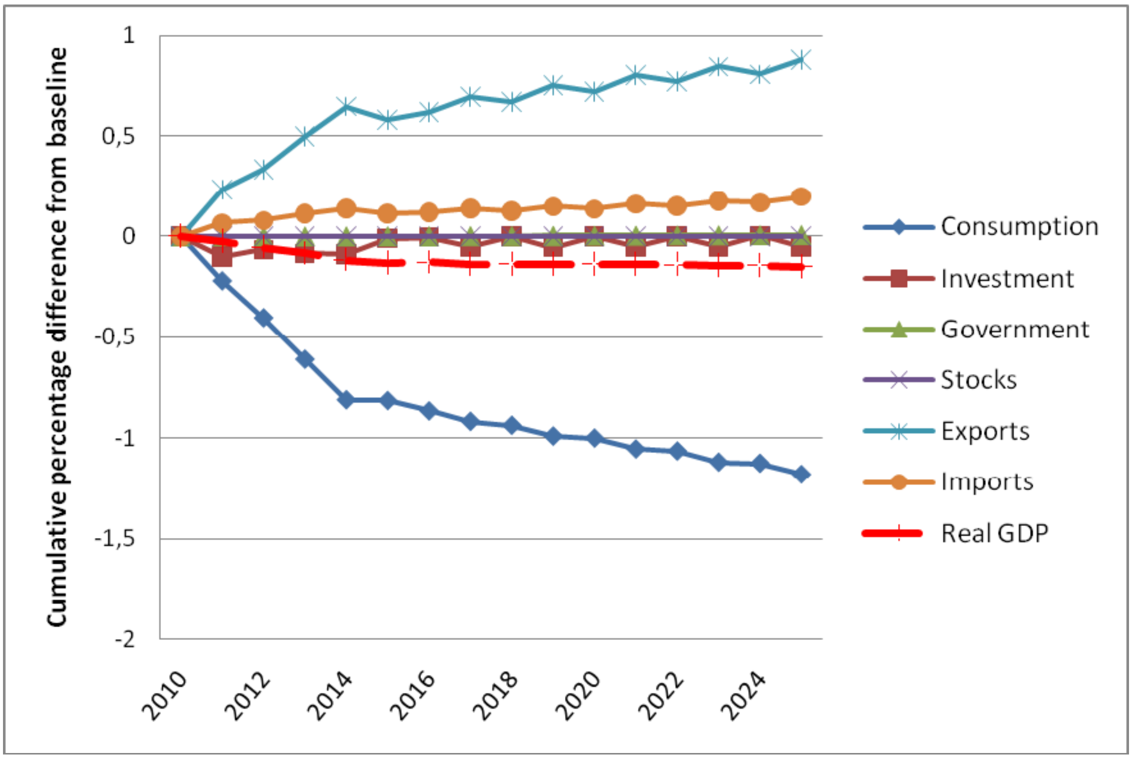


Figure 5 *Contributions to expenditure-side GDP under capital taxes*



The results for the consumption tax experiment are shown in Table 4. The rise in power of consumption taxes is 0.283 per cent, but it leads to a fall in consumption which in turn shows up as a fall in the power of taxes on GDP. The BOTE implies a 028 per cent fall in real wages, which is highest of all the three taxes considered here. Again, the simple BOTE overestimates the effect on positive effect on labour demand and on GDP, but in the actual simulation, the fall in indirect tax revenue is accounting for most of the fall in GDP for the first years of the simulation, as can be seen from Figure 6. Once the taxes cease to rise, after 2014, real wages no longer fall, and in the longer run the demand for labour ceases to grow. Even under consumption taxes labour is directed to the exporting sectors. Invesment in these sectors grows, but this is offset by the decrease in investment in service sectors, which is why the contribution of primary factors to GDP is ultimately negative.

Table 4 The effect of taxes on consumption

	2010	2011	2012	2013	2014	2015
Tg	0.000	-0.025	-0.018	-0.017	-0.016	0.003
Tl	0.000	0.000	0.000	0.000	0.000	0.000
Tc	0.000	0.283	0.261	0.246	0.229	-0.014
Technological change	0.000	-0.045	-0.036	-0.036	-0.032	0.003
Pre-tax real wage (BOTE)	0.000	-0.277	-0.235	-0.223	-0.207	0.012
Pre-tax real wage (SIM)	0.000	-0.257	-0.271	-0.237	-0.233	-0.015
Post-tax real wage (SIM)	0.000	-0.257	-0.271	-0.237	-0.233	-0.015
Employment (BOTE)	0.000	0.075	0.079	0.069	0.068	0.004
Employment (SIM)	0.000	0.022	0.012	0.019	0.016	0.001
Real GDP (BOTE)	0.000	0.004	0.016	0.010	0.012	0.006
Real GDP (SIM)	0.000	-0.031	-0.028	-0.023	-0.022	0.004

Figure 6 Contributions to income-side GDP under consumption taxes

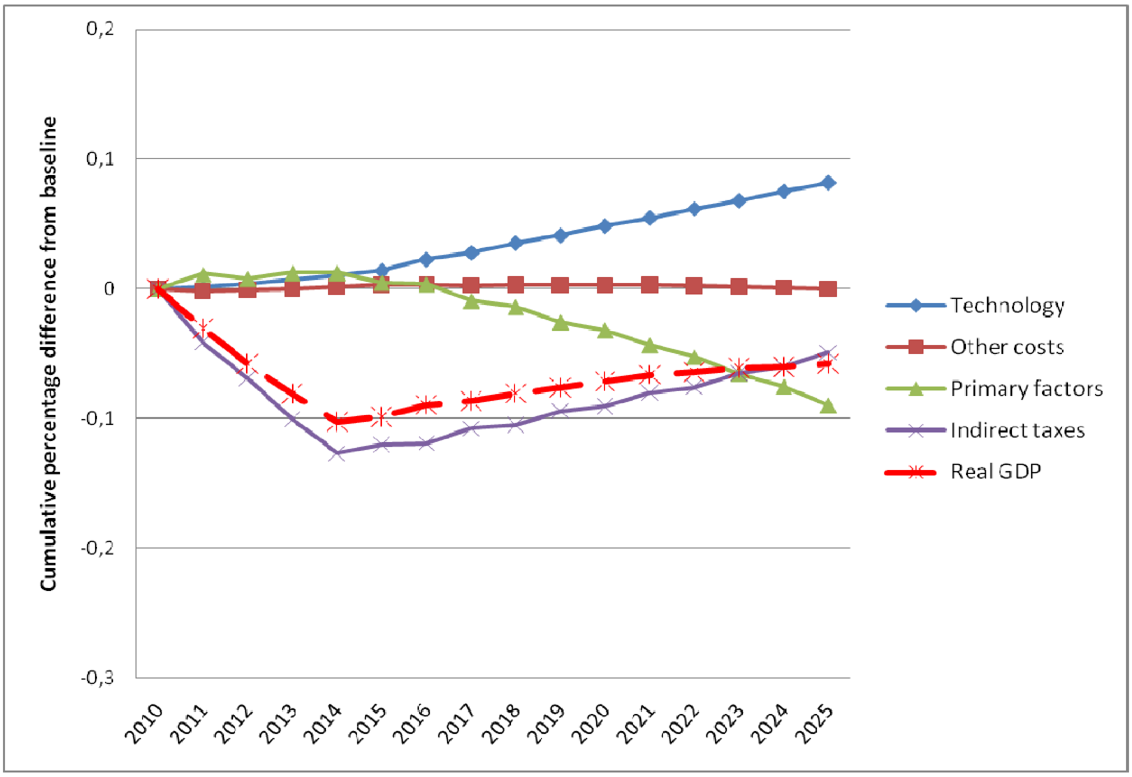
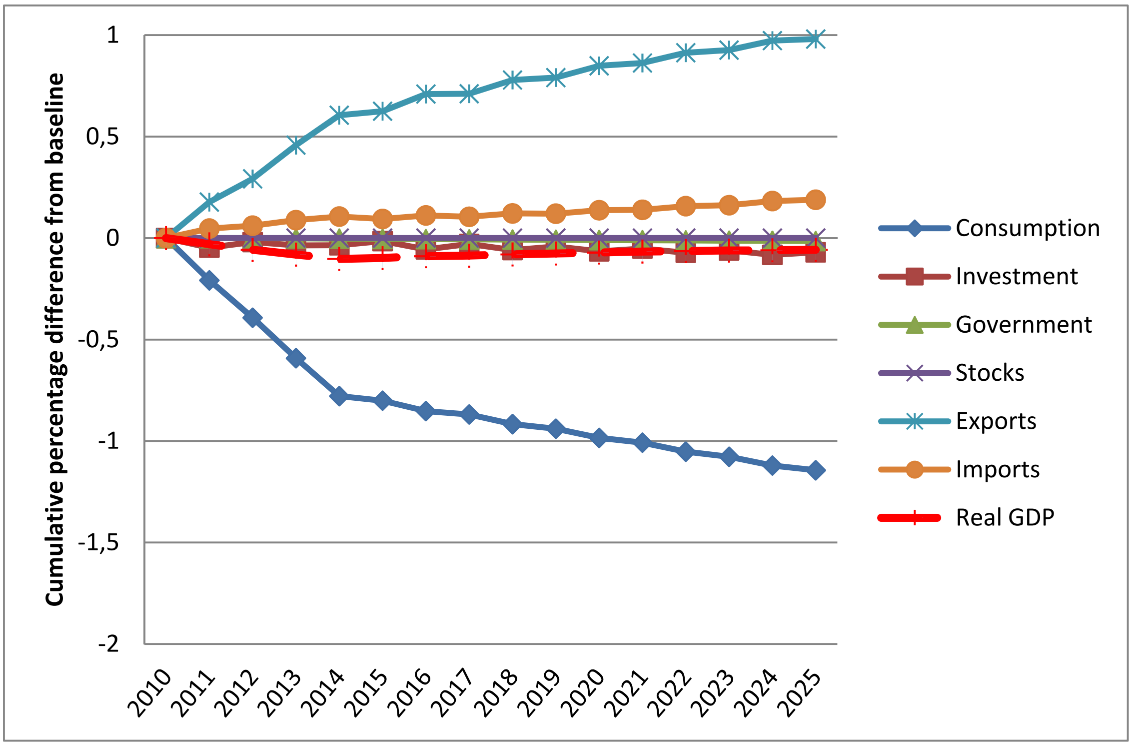


Figure 7 Contributions to expenditure-side GDP under consumption taxes



1.5.2 The welfare and efficiency effects of labour, capital, and consumption taxes

We now turn to the welfare effects of the three taxes. Figures 8, 9 and 10 show the decomposition of the welfare effects in the components derived in section 1.4.5 above. It is apparent that, under the assumption of perfectly competitive labour markets, the unemployment effect is not contributing to the overall results. Similarly, since we have fixed government spending, there is no contribution from government consumption either. The import effect also plays a minor role here. Thus the results are dominated by the intertemporal and terms of trade effects but the differences between the taxes are largely due to the leisure effect, as can be seen from Table 5 below, which concentrates on the results for a single year, namely, 2014.

The employment-leisure effect is driven by what happens to employment (n). In the absence of involuntary unemployment (assumed in these simulations), n is determined by the choice of leisure. With the consumption tax, households choose less leisure than with the labour tax. Correspondingly they choose more work (a higher value for n) with a consumption tax than with a labour tax. This gives a higher value for the employment-leisure effect under the consumption tax.

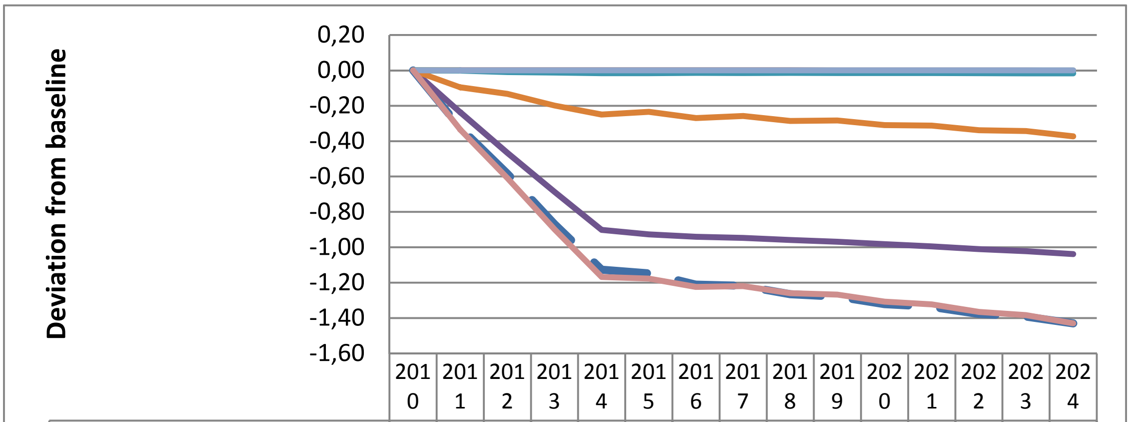
The key to understanding this result is to recognise that with no involuntary unemployment, and exogenous national savings, the major welfare problem of taxes is that they reduce the price of leisure relative to the price of consumption and saving. This encourages leisure and discourages work, but because of tax effects an, extra hour of work generates more welfare than an extra hour of leisure. The reason that the employment-leisure effect is less positive[4] for labour taxes than for consumption taxes is that the reduction in the relative price of leisure is greater for labour taxes than for consumption taxes, whereas under capital taxes, the fall in the relative price of leisure is the lowest of all.

Table 5 Welfare decomposition for 2014

	Labour taxes	Consumption taxes	Capital taxes
Govt. consumption effect	0.00	0.00	0.00
Import effect	0.00	0.00	0.00
Intertemporal effect	-0.90	-0.90	-0.90
Leisure effect	-0.02	0.03	0.06
Terms-of-trade effect	-0.25	-0.25	-0.26
Unemployment effect	0.00	0.00	0.00
Total effect	-1.17	-1.13	-1.11

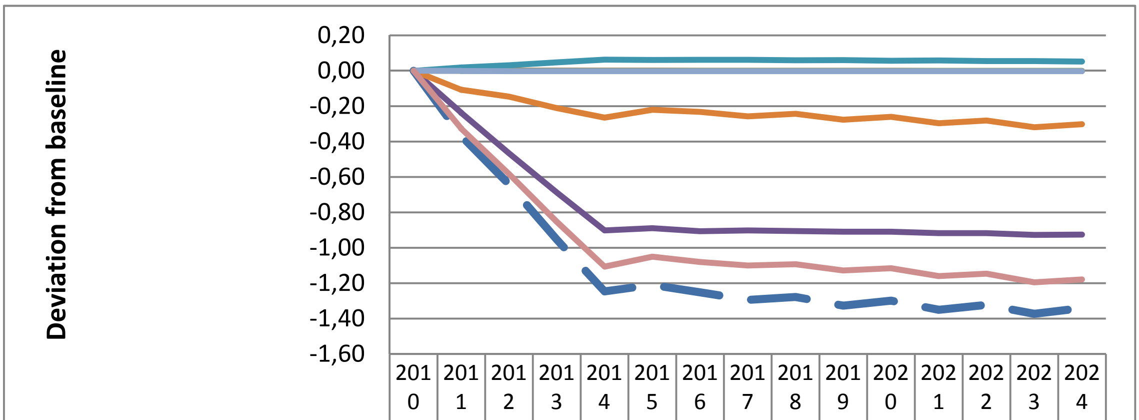
[4] With either tax the employment/leisure effect is positive. This reflects positive income elasticities of demand. With either tax in place, households cut back on current consumption, deferred consumption and leisure. A reduction in leisure means that they choose more employment.

Figure 8 *Welfare decomposition for the effects of labour taxes*



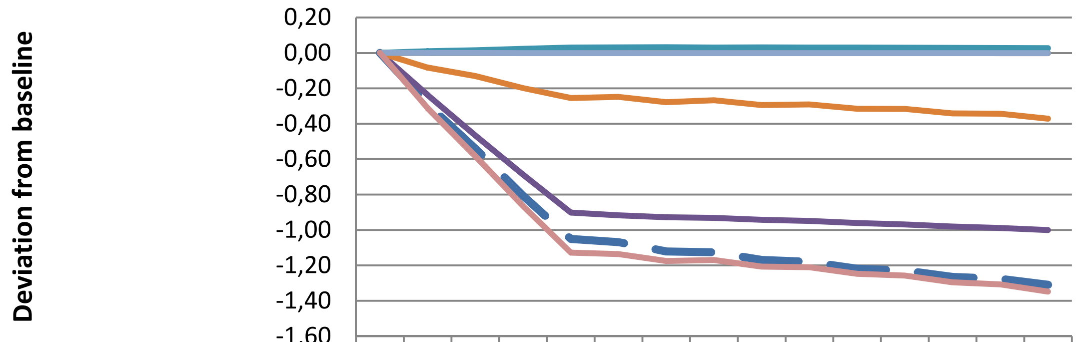
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
EV	0,00	-0,32	-0,58	-0,87	-1,13	-1,15	-1,21	-1,22	-1,27	-1,28	-1,32	-1,34	-1,38	-1,39	-1,43
Govt. consumption effect	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Import effect	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Intertemporal effect	0,00	-0,24	-0,47	-0,69	-0,90	-0,93	-0,94	-0,95	-0,96	-0,97	-0,98	-1,00	-1,01	-1,02	-1,04
Leisure effect	0,00	0,00	-0,01	-0,01	-0,02	-0,02	-0,01	-0,02	-0,01	-0,02	-0,01	-0,02	-0,02	-0,02	-0,02
Terms-of-trade effect	0,00	-0,10	-0,13	-0,20	-0,25	-0,23	-0,27	-0,26	-0,29	-0,28	-0,31	-0,31	-0,34	-0,34	-0,37
Unemployment effect	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total contributions	0,00	-0,33	-0,61	-0,90	-1,17	-1,18	-1,22	-1,22	-1,26	-1,27	-1,31	-1,32	-1,37	-1,38	-1,43

Figure 9 *Welfare decomposition for the effects of capital taxes*



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
EV	0,00	-0,37	-0,64	-0,95	-1,25	-1,21	-1,25	-1,29	-1,28	-1,33	-1,30	-1,35	-1,32	-1,37	-1,34
Govt. consumption effect	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Import effect	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Intertemporal effect	0,00	-0,24	-0,47	-0,69	-0,90	-0,89	-0,91	-0,90	-0,91	-0,91	-0,91	-0,92	-0,92	-0,93	-0,93
Leisure effect	0,00	0,02	0,03	0,05	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,05
Terms-of-trade effect	0,00	-0,11	-0,15	-0,21	-0,26	-0,22	-0,23	-0,26	-0,24	-0,28	-0,26	-0,30	-0,28	-0,32	-0,30
Unemployment effect	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total contributions	0,00	-0,33	-0,58	-0,85	-1,11	-1,05	-1,08	-1,10	-1,09	-1,13	-1,12	-1,16	-1,15	-1,19	-1,18

Figure 10 *Welfare decomposition for the effects of consumption taxes*



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
EV	0,00	-0,29	-0,54	-0,81	-1,05	-1,07	-1,12	-1,13	-1,17	-1,18	-1,22	-1,23	-1,26	-1,28	-1,31
Govt. consumption effect	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Import effect	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Intertemporal effect	0,00	-0,24	-0,47	-0,69	-0,90	-0,92	-0,93	-0,93	-0,94	-0,95	-0,96	-0,97	-0,98	-0,99	-1,00
Leisure effect	0,00	0,01	0,01	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
Terms-of-trade effect	0,00	-0,08	-0,13	-0,20	-0,25	-0,25	-0,28	-0,27	-0,29	-0,29	-0,32	-0,32	-0,34	-0,34	-0,37
Unemployment effect	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total contributions	0,00	-0,31	-0,58	-0,86	-1,13	-1,14	-1,18	-1,17	-1,21	-1,21	-1,25	-1,26	-1,29	-1,31	-1,35

We next turn to the effects on government revenues. Our experiment has assumed a fixed target for national saving, keeping real government demand constant. However, since a large part of government transfer expenditures are indexed, the implications for government revenues and government deficits can be expected to differ between the experiments, since we have shown that prices will behave differently under the three taxes. This can be seen in Figures 11 and 12, which show changes in net tax revenues and the level changes in government deficits, compared to the equivalent variations in consumer welfare. From the figures, it is clear that the labour tax will raise more revenue than the other two taxes under the national saving target, but it will also have the largest absolute welfare effects. It would appear difficult to compare the relative merits of the taxes without taking into account the relative gain in revenue in proportion to the loss of welfare. But then, this is precisely what our MCF measure does.

Figure 11 Welfare effects and total net tax revenue for labour, capital, and consumption taxes

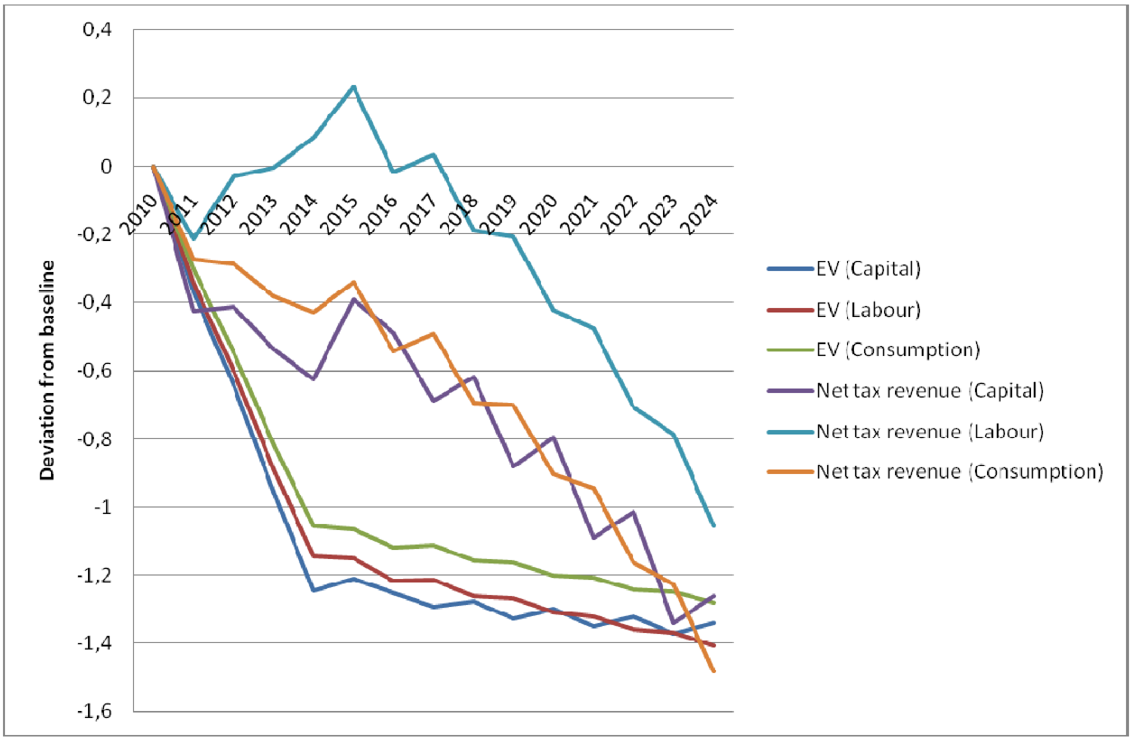


Figure 12 Welfare effects and government deficit for labour, capital, and consumption taxes

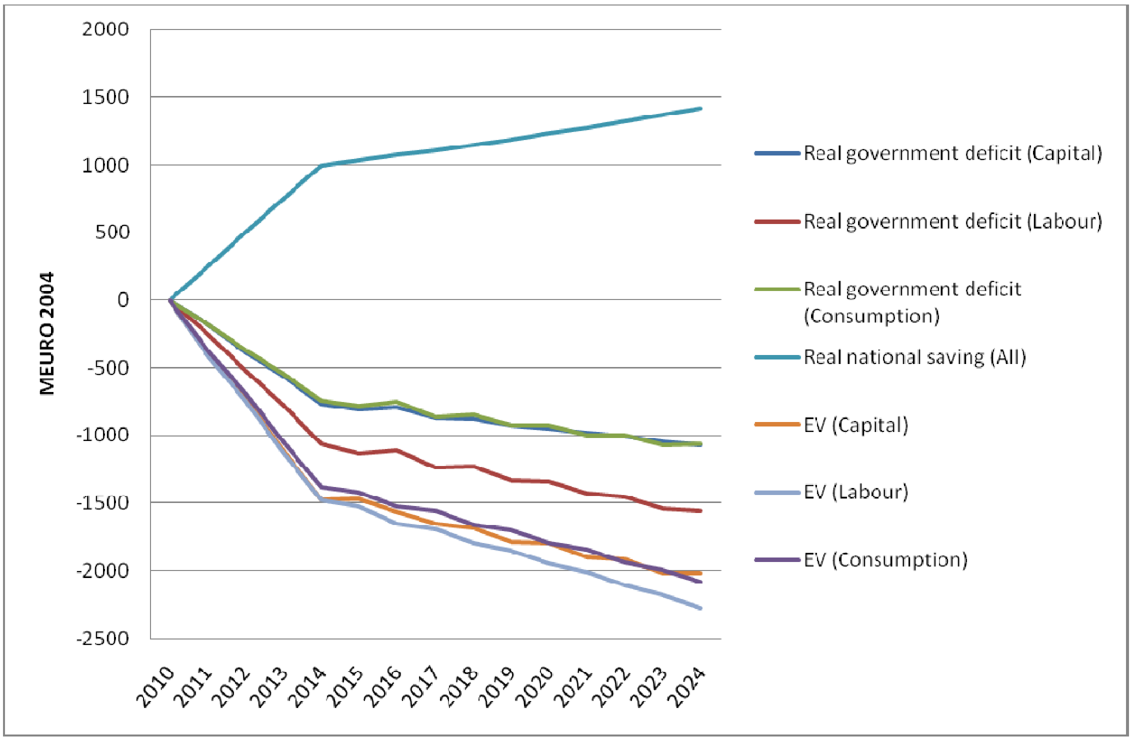
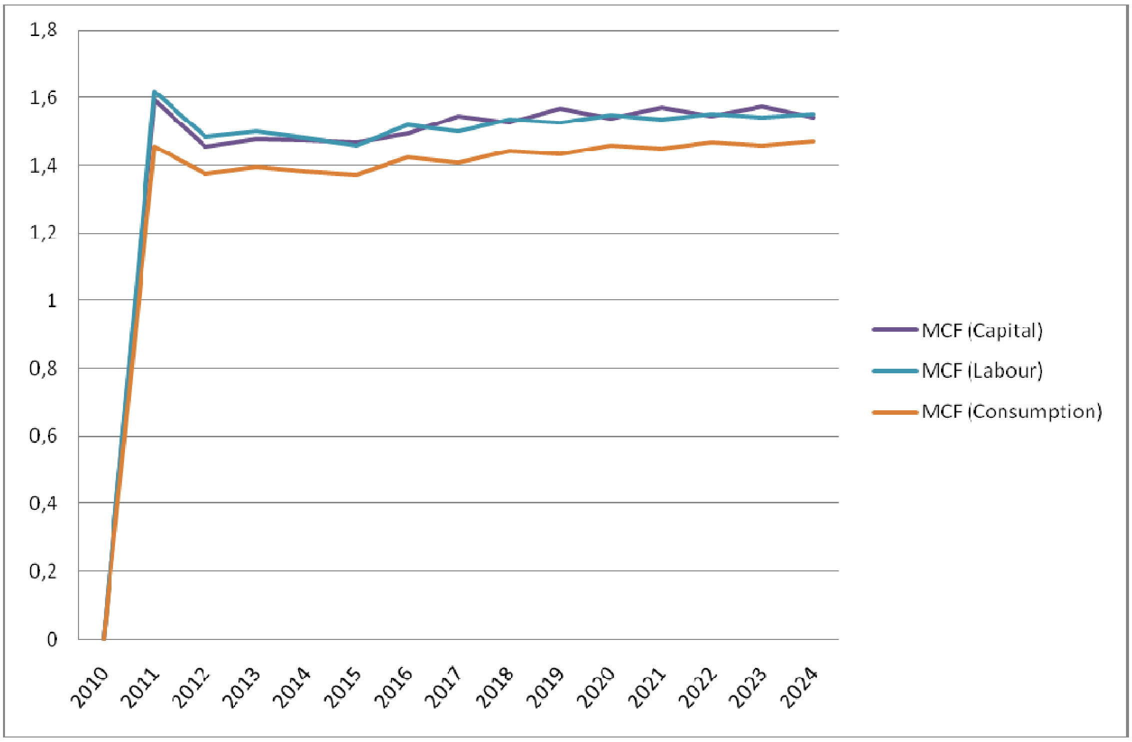


Figure 13 shows the marginal cost of funds for the three taxes. The labour tax and capital tax have a higher efficiency cost than consumption taxes. We estimate that the MCF from labour taxes is around 1.5-1.6, the MCF for capital taxes almost as high, and the MCF from consumption taxes around 1.4-1.5. These estimates fall in the range of findings from other countries. Obviously, a number of assumptions affect our estimates. We shall discuss the most important of them in the concluding section.

Figure 13 Marginal cost of funds for labour, capital, and consumption taxes



1.6 Concluding remarks

In this study, we have extended the VATTAGE model to include labour/leisure and savings/consumption choice. We have done this to facilitate the application of the model in the estimation of the marginal cost of raising funds from labour, capital and consumption taxes. We have used back-of-the-envelope model for explaining results from a full-scale dynamic AGE model on the welfare effects of the imposition of the taxes. Back-of-the-envelope equations are necessary for figuring out how an AGE model works and what has been taken into account in any set of results and what has been left out.

We find that, under perfectly competitive labour markets, welfare effects are dominated by intertemporal, terms-of-trade, and leisure effects. According to our estimates, MCF is larger for labour than capital and consumption taxes, which can be explained by the effects of the taxes on real wages with the BOTE model. This possibility is discussed in the theoretical literature on MCF as well, but here, we can establish the differing <actual tax bases as the root of the differences between the scenarios.

We find that intertemporal effects contribute equally much to welfare losses under all of the taxes. Terms-of-trade effects, in contrast, vary more between the scenarios. This may be due to the taxes affecting capital formation differently, which will eventually have an effect on relative export prices.

We have found it challenging to exclude non-tax related policies from our tax experiments. This difficulty is recognized in literature (e.g Dahlby 2008), who discusses the effects of relative prices on the measures of MCF. Dahlby also emphasizes the scale-dependency of MCF. We have deliberately chosen a policy target that is not directly linked to the prices of public expenditure – national saving – but since any of the taxes we consider will affect the ability of other taxes to raise revenue, and, moreover, the nominal level of government transfer expenditure, we expect that the implications of different taxes for government deficits are different. Our approach has the advantage of excluding scale effects.

The paper shows that it is possible to compare the efficiency costs between tax instruments with a dynamic AGE modeling approach, and to isolate the key reasons for the differences between the taxes. This provides a powerful tool for analyzing the effects of taxation.

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2. The dynamic effects of a tax reform in Finland

Juha Honkatukia – Saara Tamminen

2.1 Introduction

Several studies have analyzed effects of tax reform proposals with Applied General Equilibrium (AGE) models. While most of these studies have used static models, they all demonstrate the difficulty of focusing on the effects stemming from the tax structure itself. This is especially the case when a reform aims at revenue neutrality or a given revenue target, since changes in taxation tend to affect the costs of public spending as well. Moreover, most studies find that rigidities affect the efficiency costs of taxation. Many of the studies also show that a tax reform may give rise to distributional issues.

In this chapter, we use a dynamic AGE model of Finland to study a recent tax reform proposal under alternative assumptions about other policies. We also study the effects of wage rigidities on the effectiveness of the reform. We use the VATTAGE AGE model of Finland to estimate the dynamic effects of the proposed tax structure changes and the marginal welfare cost of these changes in the collection forms of public funds.

VATTAGE is well suited for the analysis of tax structure changes as it includes all major tax types and has a detailed industry dimension for the Finnish economy at great sector detail. Here, the model is extended to cover decile-specific employment/leisure and saving choices, based on the representative household model developed in Dixon, Honkatukia, and Rimmer (2011).

We focus on the tax reform proposal published in 2010 by the Finnish Tax Committee, consisting of experts and representatives of interest groups. Broadly, recognizing the results from previous research, which has found income and corporate taxes the most distortionary with regard to economic growth and employment, and consumption based taxes and property income taxes less distortionary, in its report (VM, 2010) the committee proposed to:

1) cut income and corporate tax rates; and
2) raise the capital tax rate, value added taxes and excise taxes.

Our previous work broadly supports the basic assumptions behind the committee's proposal. In particular, according to our estimates, the Marginal Cost of Funds (MCF), which compares the welfare loss from taxation to the revenue raised, is in Finland considerably higher for wage and capital income taxes than for consumption taxes.

Here, we use the concept of the MCF to study the effects of the proposal and to demonstrate, which factors may affect its success. Underlying our interest for measuring the efficiency of taxation and tax reforms is the well-known result from general equilibrium theory, found in e.g. Dahlby (2008) and Liu (2004), that a government should aim at a tax structure where the marginal cost of funds for each tax type is the same. The literature also suggests that the interactions between different taxes, as well as the changes in the cost of public sector production induced by a tax reform, will have an effect on MCF. The MCF analysis of Liu (2004) takes into account these effects by basing the estimate for MCF on public excess revenue, that is, gross revenue less expenditure, while keeping both public sector inputs and outputs constant. Our measure for government revenue is in essence similar to Liu's, and we also fix government expenditure and investment in real terms.

Our aim is to analyze the effects of the tax reform on efficiency and income distribution. While our central scenario will assume perfect competition and flexible wages, many previous AGE studies on tax reforms suggest that rigidities in the labour market may affect the efficiency of a reform. Thus, for example, Chisario and Cicowiez (2010) find that the welfare cost of taxation depends on regulatory regimes and also on wage formation, with real wage rigidity increasing especially the marginal cost of funds for labour taxes significantly compared to scenarios with more flexible real wages. Similarly, we find that wage rigidities can undermine the efficiency gains of the reform.

Some studies also examine capital taxes. For example, Radulescu and Stimmelmayr (2010), using a static AGE model, find that the capital tax reform of 2008 in Germany that increased the capital gains tax, lead to a decrease in GDP, investment and labour demand. Duarte Lledo (2005) uses a dynamic, overlapping generations AGE model to calculate the effects of a replacement of corporate taxes and financial transaction taxes in Brazil by a broad-based, uniform federal VAT. He finds that while the reform would not decrease incomes, it would have distributional effects. In the Finnish case, in contrast, the corporate and capital tax reform would likely encourage investment on balance. We also find that the reform would have distributional effects, the magnitude of which depends on nominal rigidities in the labour markets and also on the social security -related transfers from the government to the households. Furthermore, we find that sector effects are important not only for the structure of output but also for the distribution of factor incomes between the deciles.

The structure of this chapter is as follows. The second section gives an outline of VATTAGE and discusses the effects of income taxes under the new decile specification. Section 2.3 presents our analyses of the tax reform proposal studying macro-level effects, distributional effects, effects on different industries, and finally, analyzing the proposal from the point of view of efficiency and sustainability. Section 2.4 concludes.

2.2 The VATTAGE model

2.2.1 An outline of VATTAGE

VATTAGE is an applied, dynamic general equilibrium model for Finland that covers the whole economy and models all major tax types including labour income taxes, capital taxes and indirect taxes of various forms. The VATTAGE database contains detailed information about commodity and income taxes as well as the expenditures and transfers of the public sector, thus covering most policy instruments available to the government. The model accounts for changes in public deficit and debt and can be used to evaluate the impact of the policy shocks on public sector sustainability. Further, the government cost structure accounts for the different types of public transfers to households, including e.g. age related benefits and unemployment benefits, as well as public investments.

VATTAGE is based on the MONASH-model developed at the Centre of Policy Studies at the Monash University. MONASH-style models are used in countries ranging from China and South Africa to the United States and Australia (Dixon and Rimmer, 2002). In Europe, models based on MONASH have been developed for Denmark, Finland, and the Netherlands. VATTAGE is described in detail in Honkatukia (2009).

To study MCF, we have extended the basic VATTAGE by allowing households to make endogenous choices between their leisure (or equivalently labour-supply), their consumption of commodities and their savings (Dixon *et al*, 2011). We
have adopted the simplest approach, treating leisure and saving (reserved consumption) as two more "commodities" in household choice. The household's problem has been amended to allow for the treatment of full income, that is, income inclusive of the value of leisure.

Formally, households i maximize the utility from

$$U_{iC}(C_i) + U_{iL}(L_i) + U_{iR}(R_i) \tag{1}$$

subject to

$$P_{iC} * C_i + P_{iR} * R_i = Z_i + \left(\frac{P_W}{T_{iW}} \right) * N_i \tag{2}$$

and

$$L_i = H_i - B_i - N_i \tag{3}$$

where

C is consumption
L is leisure
R is reserved consumption (i.e. saving)
H is total hours available for work;

B is hours in involuntary unemployment;
N is hours of employment;
P_W is the pre-tax wage rate;
T_W is the power of the tax on labour income;
Z is household non-labour income;
P_R is the price of a unit of reserved consumption (to be discussed in subsection 2.2.6);
P_C is the price of a unit of consumption,
and where the index i denotes decile.

In (3), we assume that involuntary unemployment is not leisure and consequently gives no utility.

The price of consumption is given by

$$P_{iC} = P_Y * T_{iC} \tag{4}$$

where
T_{iC} is the power of the tax on consumption (that is, 1 + ad valorem-equivalent rate of commodity taxes), P_Y is the price of GDP.

The first order conditions from problem (1) to (3) are:

$$U^{/}_{iC}(C_i) = \lambda_i * P_Y * T_{iC} \tag{5}$$

$$U^{/}_{iL}(L_i) = \lambda_i * P_{iW} / T_{iW} \tag{6}$$

$$U^{/}_{iR}(R_i) = \lambda_i * P_{iR} \tag{7}$$

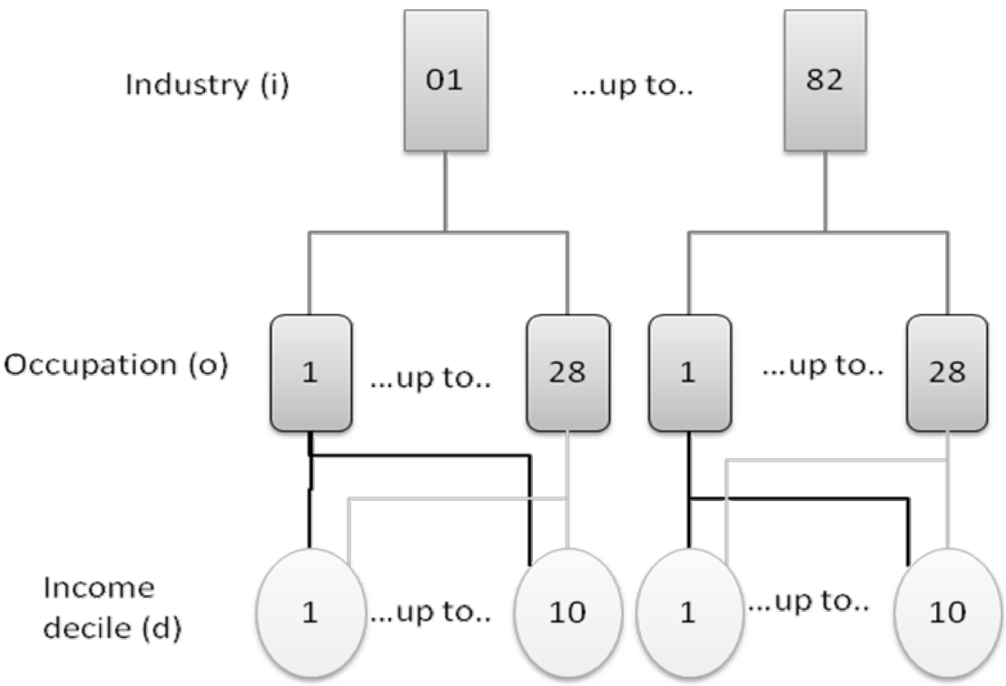
where
the superscript prime denotes derivative; and
λ is the Lagrangian multiplier which can be interpreted as the increase in utility that the household would derive from an extra dollar of income (a unit increase in Z).

As is apparent from the demand equations, consumption of commodities, leisure and saving are now interrelated, whereas in the original formulation of VATTAGE, the labour market specification drives the reaction of employment to taxes, and saving is affected by taxation only to the extent that households' disposable incomes change.

In specifying the demand functions arising from (5)-(7), we assume that the relevant price for leisure is the nominal after tax wage rate, whereas the price of saving captures the opportunity cost of current consumption.

To link the consumption and labour supply choices, we have coupled data on decile-specific consumption with data on decile-specific income. On the income side, our databases cover decile and occupation-specific labour, capital and transfer incomes. To link this data to labour demand by the 82 VATTAGE industries, we use industry and occupation specific labour data. This enables us to link the two data sets, as illustrated in Figure 1.

Figure 1 Labour income by occupation and decile



To calibrate the labour supply elasticities implied by the utility maximization problem in (1) to (3), we have used the estimates of Kleven and Kreiner (2006), who find considerably higher elasticities for lower income deciles than for higher ones. On the average, the implied elasticity of supply is here around 0.1, with the elasticity in the lowest two income deciles nearing 0.2-0.3 but being well below 0.1 for the higher-income deciles.

Decile-specific consumption data stems from VATT's income-distribution model (TUJA). The parameters for the decile-specific consumption functions cover 91 commodities, and have been estimated using the large consumption data bases of the income-distribution model. They are reported in Honkatukia, Kinnunen and Rauhanen (2011).

2.2.2 Baseline scenario

The literature on MCF suggests that welfare costs are scale-dependent. This means that the baseline scenario of the economy matters for the results of the analysis. VATTAGE baseline is constructed to conform to medium-term official forecasts at the macro level. However, at the sector level, it is based on an extensive study of the structural trends of the economy, as well as a very large scale foresight effort encompassing dozens of sector and regional experts. This section gives a brief description of the procedures followed in forming the baseline.

The structural trends concern changes in demand patterns by commodity and user (domestic consumption, exports to EU and elsewhere, investment, and the public sector) that stem from a historical analysis of the development of the Finnish economy (Honkatukia and Marttila 2011). In the historical analysis, VATTAGE uses data on the actual changes in demand, production, relative prices and the tax structure over a period of the time to decompose the observed changes in the economy into contributions by structural variables. For example, historical analysis allows us to show that the largest contribution to the 37.3 per cent GDP growth from 1995 to 2004 stemmed from employment, which alone would have explained a 15.7 per cent increase in GDP. More importantly, we find that technological change – mainly primary factor productivity growth – explained 8.3 per cent of GDP growth, while trade and domestic prices together explained more than 10 per cent of GDP's growth. The historical analysis is conducted at commodity and industry level and allows us to obtain trends for the development of factor productivity and demand patterns, which can be used in forecasting the baseline for the future.

The baseline forecast also uses macro and, to an extent, industry level forecasts from other studies. We use macroeconomic forecasts for the early years of the scenario, and population and age-related expenditure forecasts for the whole scenario. The main medium-term macroeconomic assumptions in our scenario conform to the medium term forecast of the Ministry of Finance and the EU Ageing Working Group. In the longer run, macroeconomic development is determined by population trends, which affect public demand for services and other public expenditures, as well as private consumption, whereas industry-level development depends on productivity trends and commodity-level export trends. The baseline also evaluates the development of public sector debt and deficit, given policy measures already taken. The sector-specific baselines have been developed in the context of a long term foresight project, where we have benefitted from the scrutiny and comments of dozens of sector and regional experts and interest groups (Honkatukia, Ahokas and Marttila, 2010; Ahokas and Honkatukia, 2010).

2.2.3 A Back-of-the-envelope model of the effects of income tax cuts

One of the key findings of the MCF literature is that labour supply responses have a large impact on the efficiency of the tax system. In this section, we study the labour supply responses in VATTAGE to changes in labour income taxes and to changes in taxes on transfers, which form a significant part of the Tax Committee's proposal. To see what the responses depend on, we use a stylized model of the full simulation model, a back-of-the-envelope (BOTE) model, to see what the crucial mechanisms are and how they can be expected to work in the full simulation.

The link between labour supply decisions and production can be illustrated with a simple back-of-the-envelope model of the full model. For simplicity, we shall only consider value added, which, for the whole economy, is given by

$$Y = A * F(K, L) \quad . \tag{8}$$

VATTAGE assumes that investment takes time. Since we want to study the short-run connections between taxes, labour supply and production, we can then focus on the short run production function (assuming a fixed capital stock), given by

$$Y = A * F\left(\frac{K}{L}\right) \tag{9}$$

We assume that labour is paid its value marginal product, which is given by

$$W = \frac{P_g}{T_g} * A * f\left(\frac{K}{L}\right) \tag{10}$$

where

W is the nominal before-tax wage rate; P_g is the price deflator for GDP;

T_g is the power of indirect taxes applying to production in Finland, power of a tax being defined as (1 + ad valorem-equivalent rate of indirect taxes); and

$A * f(K/L)$ is the marginal product of labour derived from the constant-returns-to-scale production function, Y= A*F(K,L).

Thus the real pre-tax wage level is given by

$$\frac{W}{P_c} = \frac{P_g}{T_g} * A * f\left(\frac{K}{L}\right) * \frac{1}{P_c} \tag{11}$$

where

W is the nominal pre-tax wage rate;

T_w is the power of the tax on labour income (1+ tax rate on labour income); and P_c is the price deflator for consumption.

Consumer prices are linked to the price of GDP by $P_c = P_g * T_c$, where T_c is the power of consumption taxes (1+ad valorem equivalent rate).

With a CES production function, the short-run changes in the marginal product of capital are given by

$$\%\Delta f = -\frac{S_k}{\sigma} l \tag{12}$$

where l is the percentage change in employment, S_k is the capital share in returns to primary factors and σ is the elasticity of substitution between capital and labour.

The consumer's utility maximization problem implies that labour supply is linked to the demand for leisure, with the price of leisure being given by the after-tax real wage, and of full income, which in turn is also affected by real wages. Thus we have a link between labour supply and real wages, which is of the form

$$l = \varepsilon * (w - p_c - t_w) \tag{13}$$

where ε is the elasticity of demand for labour supply with respect to pre-tax real wages, and where the lower case variables w, p_c, and t_w are the percentage changes in the respective upper-case variables for nominal wage level, consumer prices and the power of wage taxes, respectively. ε depends on the share of labour income, as well as the elasticity of substitution between leisure and other consumption. We have calibrated the latter to imply an average supply elasticity of 0.1, following Kleven *et al*. (2006).
Substituting (13) and (12) in (11), we have, for the percentage change of the pre-tax real wages,

$$w - p_c = C_1 * \left(t_g + t_c - a - C_2 * t_w\right), \tag{14}$$

where

$$C_1 = \frac{-1}{\left(1 + \frac{S_k * \varepsilon}{\sigma}\right)}, \tag{15}$$

and

$$C_2 = \frac{S_k * \varepsilon}{\sigma}, \tag{16}$$

and where σ is the elasticity of substitution between capital and labour and t_c the percentage change in the power of consumption taxes. Under our specification, with a capital share from value added at around 0.35, the value of C_1 is roughly -0.84, whereas C_2 is roughly 0.18.

Equation (14) gives a concise BOTE formula for understanding the aggregate effect of changes in taxes on real wages. We can use this for interpreting the results, and also for forming a prior for the expected simulation results.

To study how an income tax cut may affect labour supply, we first simulate the effects of a cut in taxes on wage income alone. Under our assumption of phasing-in, the tax rate on labour income would fall by about 2.3 per cent on the average each year between 2012 and 2015.

Table 1 BOTE for results of wage tax cuts (deviation)

	2011	2012	2013	2014	2015
Tg	0.00	0.00	0.00	0.00	0.00
Tl	0.00	-0.48	-0.96	-1.43	-1.90
Tc	0.00	-0.04	-0.03	-0.05	-0.05
Technological change	0.00	0.04	0.09	0.13	0.18
Pre-tax real wage (BOTE)	0.00	0.00	-0.04	-0.05	-0.07
Pre-tax real wage (SIM)	0.00	0.02	0.12	0.22	0.37
Post-tax real wage (Bote)	0.00	0.48	0.92	1.38	1.82
Post-tax real wage (SIM)	0.00	0.50	1.08	1.67	2.30
Labour supply (BOTE)	0.00	0.05	0.09	0.14	0.18
Labour supply (SIM)	0.00	0.01	0.01	0.00	-0.02
Employment (SIM)	0.00	0.01	0.01	0.00	-0.02
Real GDP (BOTE)	0.00	0.07	0.06	0.09	0.11
Real GDP (SIM)	0.00	0.05	0.10	0.13	0.17
Consumption (SIM)	0.00	0.30	0.59	0.94	1.30
Investment (SIM)	0.00	0.39	0.16	0.34	0.24
Exports (SIM)	0.00	-0.38	-0.53	-0.92	-1.24
Imports (SIM)	0.00	0.21	0.27	0.42	0.50

The results of this simulation for the first years of the policy are shown in Table 1 as deviations from baseline (i.e. cumulative per cent changes). From the table, it can be seen that the policy cuts the power of labour taxes by half a per cent in 2012. It also affects the average power of consumption taxes. This is due to distributional effects both in consumption patterns and over deciles: the overall consumption of highly taxed commodities increases less than consumption on the average. Furthermore, overall consumption actually falls for those deciles of whose incomes wages form a large part (the lowest three income deciles). Based on equation (14), we expect real after tax wages to rise, which according to equation (13) should cause an increase in labour supply. As the table shows, this is what happens in the full simulation. Finally, based on equation (9), we can then also calculate the effect on GDP.

The effects on the GDP components shown in Table 1 can be understood starting from the labour supply response. Consider the GDP identity

$$Y = C + I + G + X - M \ . \qquad (17)$$

Recalling the short-run production function in equation (9), from the fact that more labour is now available it follows that GDP (Y) must rise in the short run (since the capital stock is fixed). From the increase in incomes it is also clear that consumption (C) rises. Both of these effects contribute to an increase in investment (I). However, since GDP increases only a little (value added only increases slightly because of the small labour input contribution), but consumption increases relatively more, there must be a reduction in (X-M) (i.e. exports less imports), since we assume that government demand (G) is fixed. The mechanism behind this is a rise in the domestic price level, which puts exports in a disadvantage and leads to a deterioration of the trade balance.

From Table 1, it is clear that BOTE overestimates the labour supply increase. This is due to the fact that the simple BOTE formula for labour supply does not consider the effects on disposable income due to the effects on the overall price level (which rises as the economy expands as a result of the tax cut boosting consumption).

The BOTE also misses effects rising from income distribution. The full simulation takes into account the effects of income tax progression, as well as the differences in the supply elasticities of labour between the deciles. In the actual simulation, both of these effects are important, since the tax breaks are smaller for the mid- and high-income deciles, whose labour supply elasticities have been estimated to be lower than average, than those of the low-income deciles, whose supply elasticities are thought to be higher than average. Overall, these effects accentuate the labour supply response; indeed, when we run the same simulation in the single-household VATTAGE, using the average elasticity of supply for labour, the labour supply increase is smaller than under the decile specification. On the other hand, if we run the decile model under the assumption of equal proportional tax cuts for each decile, the response is larger than under progression. Clearly then, tax progression and differences between the deciles' labour supply elasticities do make a difference, motivating the use of a multi-household model.

Before turning to the analysis of the full reform proposal, we consider the effects of changes in other taxes. In the proposal, the labour income tax cut is compensated for with an increase in indirect taxes. This is significant from the point of view of labour supply, since the resulting rise in the domestic price level will have opposite effects on real wages than the income tax cut. Table 2 shows our results for this simulation. The BOTE predicts only a small increase in post tax real wages and labour supply; in the actual simulation, real wages and labour supply rise even less by 2015. Consequently, there is no short-run boost to GDP (the slight fall in GDP is due to a negative contribution of indirect tax revenues to GDP). However, the falling pre-tax real wage is making investment more profitable, to the extent that there is a terms-of-trade adjustment also in this case.

Table 2 BOTE for results of income tax cuts and consumption tax rises (deviation)

	2011	2012	2013	2014	2015
Tg	0.00	0.00	0.00	0.00	0.00
Tl	0.00	-0.48	-0.96	-1.43	-1.89
Tc	0.00	0.42	0.84	1.25	1.67
Technological change	0.00	-0.03	-0.08	-0.13	-0.19
Pre-tax real wage (BOTE)	0.00	-0.46	-0.92	-1.39	-1.86
Pre-tax real wage (SIM)	0.00	-0.48	-0.94	-1.41	-1.87
Post-tax real wage (Bote)	0.00	0.02	0.03	0.04	0.03
Post-tax real wage (SIM)	0.00	0.01	0.01	0.01	0.02
Labour supply (BOTE)	0.00	0.00	0.00	0.00	0.00
Labour supply (SIM)	0.00	0.01	0.01	0.01	-0.01
Employment (SIM)	0.00	0.01	0.01	0.01	-0.01
Real GDP (BOTE)	0.00	-0.03	0.00	-0.01	-0.02
Real GDP (SIM)	0.00	-0.03	-0.07	-0.13	-0.19
Consumption (SIM)	0.00	-0.12	-0.25	-0.36	-0.46
Investment (SIM)	0.00	0.16	0.07	0.10	0.04
Exports (SIM)	0.00	0.01	0.07	0.01	-0.07
Imports (SIM)	0.00	-0.03	-0.12	-0.20	-0.30

Finally, we consider the effects of a cut in capital income taxes in connection with an increase in indirect taxes on intermediate inputs. The results for this simulation are given in Table 3. We estimate that the combined effect of the Tax Committee's proposals for capital and corporate taxes would amount to a one percent decline in the average capital income tax rate over the next four years. The direct effects on investment are positive, since they amount to an increase in the after-tax rate of return on investment. However, the results on investment also depend on the rest of the economy, and crucially, on the effects on labour supply.

While the cut in capital taxes does not directly enter our BOTE for real wages, indirect taxes do, and the effect of higher indirect taxes amounts to raising the power of indirect taxes on GDP by 0.06 per cent in 2012. This causes a fall in real wages, labour supply, and GDP. In the simulations, consumption is also falling because of the rise in the price level.

Table 3 BOTE for results of capital tax cuts and indirect tax rise (deviation)

	2011	2012	2013	2014	2015
Tg	0.00	0.06	0.12	0.17	0.23
Tl	0.00	0.00	0.00	0.00	0.00
Tc	0.00	0.00	-0.01	-0.01	-0.01
Technological change	0.00	-0.01	-0.02	-0.03	-0.04
Pre-tax real wage (BOTE)	0.00	-0.06	-0.11	-0.17	-0.22
Pre-tax real wage (SIM)	0.00	-0.13	-0.27	-0.39	-0.52
Post-tax real wage (Bote)	0.00	-0.06	-0.11	-0.17	-0.22
Post-tax real wage (SIM)	0.00	-0.13	-0.26	-0.39	-0.52
Labour supply (BOTE)	0.00	-0.01	-0.01	-0.02	-0.02
Labour supply (SIM)	0.00	0.00	-0.01	-0.01	-0.02
Employment (SIM)	0.00	0.00	-0.01	-0.01	-0.02
Real GDP (BOTE)	0.00	-0.01	-0.01	-0.01	-0.02
Real GDP (SIM)	0.00	-0.01	-0.03	-0.04	-0.05
Consumption (SIM)	0.00	-0.03	-0.06	-0.08	-0.10
Investment (SIM)	0.00	0.01	0.02	0.04	0.03
Exports (SIM)	0.00	-0.01	-0.03	-0.04	-0.06
Imports (SIM)	0.00	-0.02	-0.04	-0.05	-0.07

2.3 The effects of the tax reform

2.3.1 The tax committee's proposal for a tax reform

The Tax Committee published its proposal at the end of 2010. The committee was tasked with developing a model for restructuring the whole tax system, with the aim of improving the competitiveness of the Finnish economy and increasing the employment rate.

The committee proposed to make tax collection more dependent on VAT revenue instead of income and corporate taxes as previously. This change should fit the anticipated in the Finnish population structure, as the population share of pensioners is increasing, while that of the working-age population is falling. Increases in excise taxes of various commodities with negative externalities (e.g.

alcohol, lot of sugar containing products, fuels and electricity) were also proposed, based on the inverse elasticity rule[5]. Income and corporate taxes, in contrast, would be lowered in order to encourage employment and the establishment of companies. The changes were intended to be budget neutral, i.e. without effects on total tax collection.

Table 4 below presents in detail the planned changes, which have been used also as the shocks in the modelling scenarios. We impose the proposed changes on the rates implied by the model database. For most taxes, this is straightforward. We assume that the reform is phased in gradually, over the next four years starting in 2012. After 2015 all tax rates are assumed to remain unchanged.

Table 4 Proposed changes on different tax rates. Source: VM (2010), Statistics Finland

Tax type	Change in tax collection €	% change	Notifications
Income tax	-2060 million € per year	Total change in collected income taxes: -9,2 per cent, which equals average -1.75 percentage point decrease in the income tax rate.	Income deciles specific changes in income taxes were calculated from microdata with VATT's TUJA-micro simulation model.
Capital taxes	+500 million € per year	Capital tax up from 28% to 30%	-Modelled together in the VATTAGE model
Corporate taxes	-800 million € per year	Corporate tax down from 26% to 22%	
Value added taxes (VAT)	+1200 million € per year	All VAT rates 2 percentage points up	
Excise tax	+1000 million € per year	- Alcohol tax up by 10% - Candy and ice-cream tax up by 33% (on top of the tax raise of 2011) and the same tax percentage to be applied to all sweet bakings and comfiture - Tax on soft drinks up by 100% - Consumer electricity and all fuel taxes up by 10%	These increases in excise taxes are additional to the energy and sugar product tax increases of 2011.

[5] Based on this rule, the optimal tax rate of a commodity should be inversely related to the demand elasticity of the product (e.g. Dahlby, 2008). The demand elasticities of all the products listed are relatively inelastic and provide, hence, an easy target for the collection of additional tax revenue.

With regard to the excise taxes, the final report of the tax committee does not provide specific assumptions on the exact change per excise tax. The assumptions below on the per cent changes are based on the income inequality analysis of the report, p. 217 (VM, 2010).

In Finland, as in other Scandinavian countries, the **income tax rates** are progressive (i.e. depend on the income level) and, hence, the new, lower income tax rates were also defined just as a new progressive tax rates varying by income (VM, 2010). In VATTAGE, income tax rates can be defined only for the 10 different income deciles, not by the detailed progression function. Therefore, the changes in the income deciles specific average income tax rates were first calculated with household level microdata and the TUJA micro simulation model of VATT. Table 5 below specifies the calculated changes in the average income tax rate for all 10 household income deciles. The shocks in the first scenario follow strictly these new tax rates calculated by the TUJA model. The per cent changes inserted to the model as shocks are presented in the fourth column.

Table 5 Change in the average income tax rate per household income decile

Household income decile	2010 Average income tax rate*	New tax rate*	Change by 2015, %,
1	7,6	6,6	-12,8 %
2	10,7	9,9	-7,8 %
3	13,0	11,8	-9,0 %
4	14,7	13,2	-10,1 %
5	15,6	14,0	-10,4 %
6	16,7	15,0	-10,2 %
7	17,8	16,0	-9,8 %
8	19,0	17,2	-9,7 %
9	21,0	19,1	-9,4 %
10	27,4	25,1	-8,1 %
All	19,0	17,3	-9,2 %

Source: VATT, TUJA microsimulation model
* Income tax rate is specified as the average income tax percentage over a representative household in each household level income decile.

In the VATTAGE model **corporate taxes and capital taxes** are summed up to a single capital tax rate. The net effect of a decrease in the corporate tax and an increase in the capital tax on this rate was estimated on the basis of the shares of these two respective tax forms in the accumulated capital tax collection. In the model, all corporate after-tax profits are assumed to be redistributed to the households since there is no information on the (future) dividend payout ratios. In practice, the dividend payout ratios have varied heavily from year to year and only a part of the dividends of Finnish companies are redistributed nowadays to

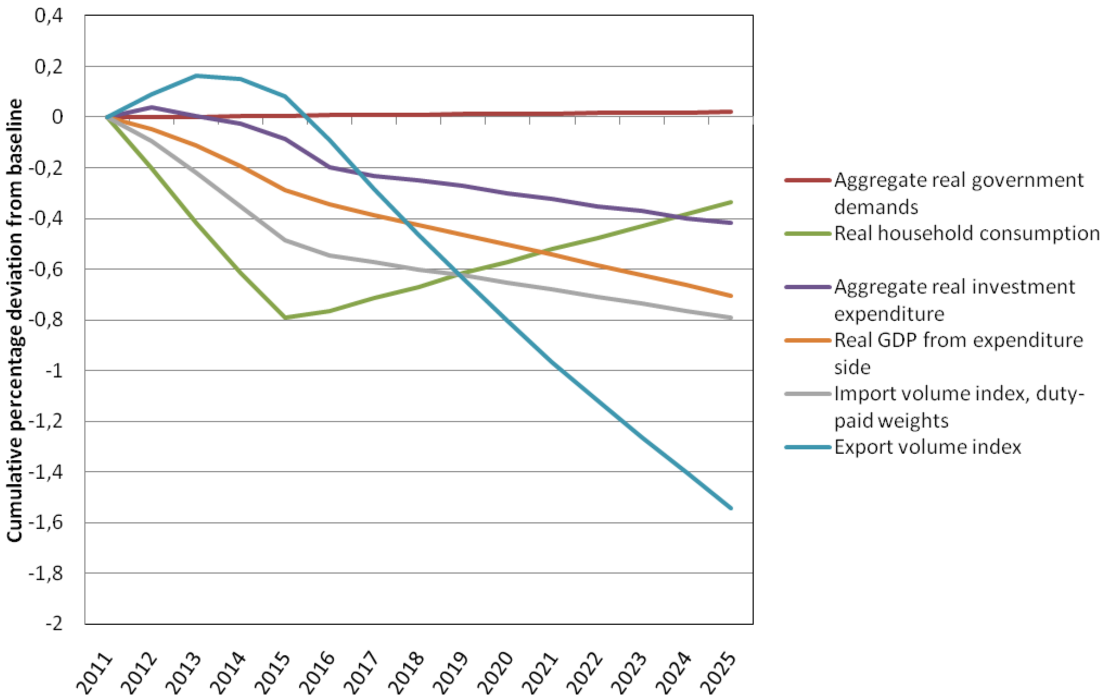
Finnish households. If corporate profits were assumed to be fully taxed again as capital income of households (as in practice corporate profits paid off as dividends are double taxed in Finland), the net shock of the two tax rate changes would be underestimated. Hence, taking the conservative approach, corporate profits distributed to the households were not assumed to be taxed again in the main modelling scenarios. In the main scenarios, the overall effect of the corporate taxes and capital income taxes then amounts to an average 1 per cent fall compared to baseline. We do, however, also consider the sector effects of the corporate tax cuts in one of our alternative scenarios, with the aim of exploring investment responses to the corporate tax cuts.

The planned additional increase of 2 percentage points in all **value added taxes (VAT)** and in the above mentioned **excise taxes** are assumed to be phased in starting 2012. VATTAGE takes in to account both the value added taxes and excise taxes among the producer's intermediate consumption tax rate and in the consumer's consumption tax rate. The changes are commodity-specific, affecting all users of a commodity in equal proportion (that is, possible initial differences in commodity tax rates between users remain in place in the simulations).

2.3.2 The macroeconomic effects of the tax proposal

We now turn to the analysis of the actual proposal. In this main scenario, we assume competitive labour markets, with flexible real wages. We assume that only taxes on wage incomes and capital incomes are cut, and that social security transfers and pensions are indexed to overall consumer prices. The effects of the policy on expenditure aggregates are shown in Figure 2 in deviation form (i.e., the level change compared to baseline expressed in percentage changes). The results can be understood with the help of equations (9) and (17); the fall in employment leads to a fall in value added according to (9); Household consumption falls because of rising prices; Investment is initially boosted by the cut in capital taxes, which raises the expected rate of return on investment; Finally, since GDP is falling at the same time as domestic absorption in growing, the trade balance must eventually deteriorate.

Figure 2 *Change in expenditure aggregates in policy*



The GDP effects can be decomposed into the contributions of changes in supply and demand components to the overall change in GDP, which shows the relative importance of each component. Figure 3 studies the contributions of the income aggregates and shows that the fall in primary factors (primarily labour) and other costs (including profits) are driving the fall in GDP. The contribution of taxes on GDP, on the other hand, is positive after a while, showing the effects of the change towards commodity taxes. Figure 4 shows the contributions of the expenditure aggregates. After the initial boost to investment, all expenditure aggregates decline. The deterioration of the trade balance, which shows as a negative contribution of exports to GDP growth, also has a positive contribution to GDP stemming from the falling imports.

Figure 3 *Contributions of income aggregates on GDP in policy*

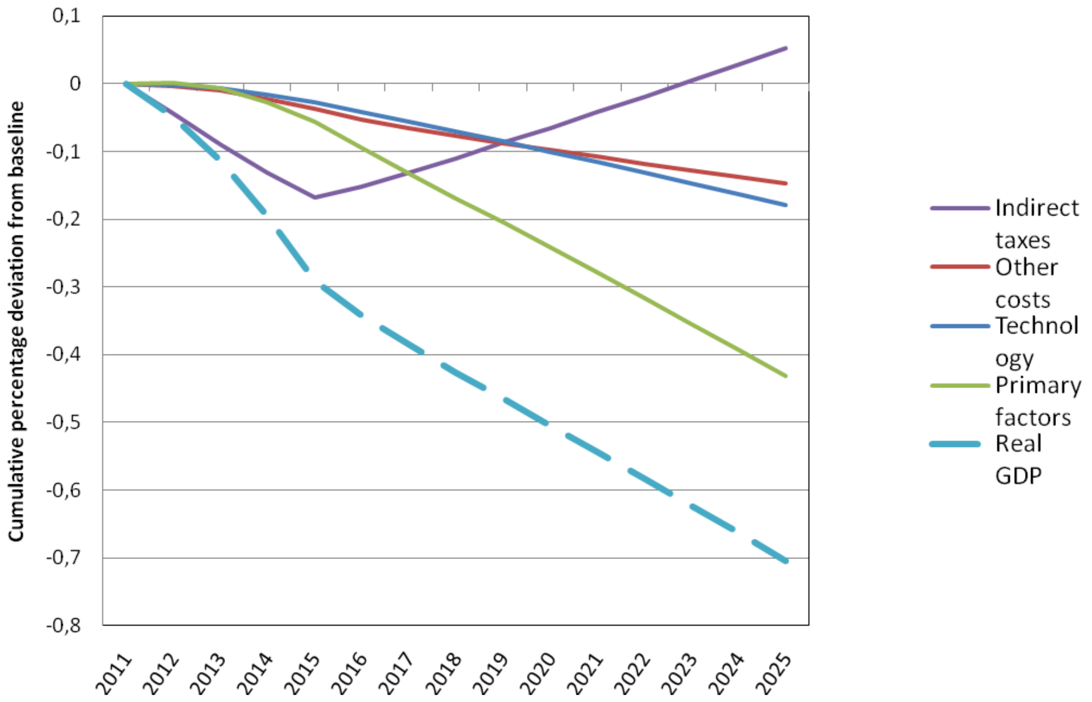
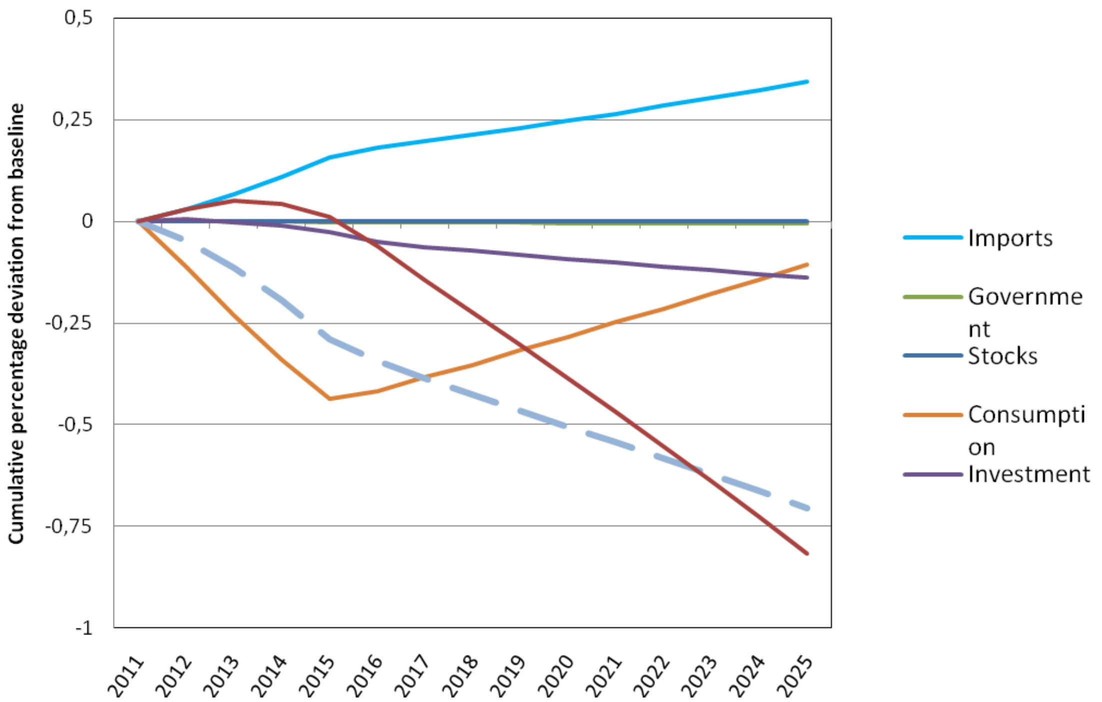


Figure 4 *Contributions of expenditure aggregates on GDP in policy*



We next study the effects of labour market rigidities on the welfare costs of a tax reform. We assume real wage adjustment to take the form

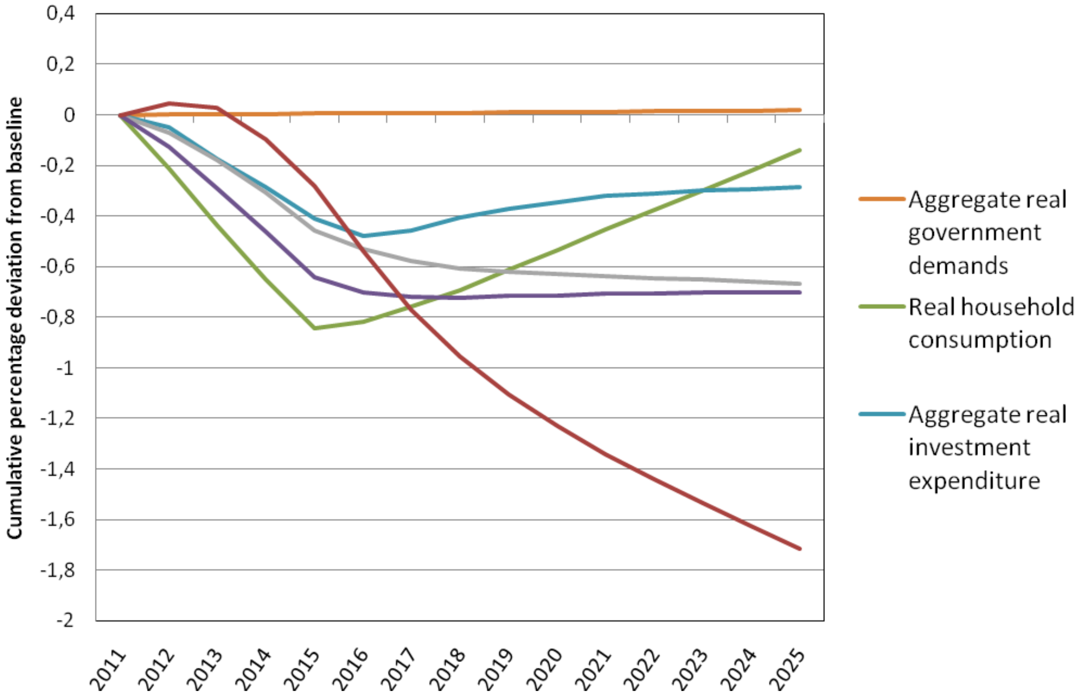
$$\left(\frac{W_t}{W_t,old}-1\right)=\alpha_1\left(\frac{W_{t-1}}{W_{t-1},old}-1\right)-\alpha_2\left(\frac{E_t}{E_t,old}-\frac{LS_t}{LS_t,old}\right), \qquad (18)$$

where α_1 and α_2 are adjustment coefficients which take the values 0.4 and 1.1, following the estimates of McMorrow and Roeger (2000). Equation (18) states that current real wages only adjust with a lag to changes from the expected (old) baseline wages (W), employment (E), and labour supply (LS). The specification in (21) is compatible with many theories about centralized wage setting, as discussed in Dixon and Rimmer (2002) and does not necessitate the explicit modelling of the wage-setting unions' target function in an application such as ours. The effect of wage rigidities following (21) in our setting is to drive a gap between labour supply and labour demand.

The main effect of wage rigidities is that adjustment to changes in taxation takes place partly via employment since now the pre-tax real wage, which is determining equilibrium employment, falls by less than under flexible wages, since it is no longer driven by utility maximization and cost minimization. As a result, there is now a more pronounced fall in employment in the short run. This shows as a gap between labour supply – which is still determined by households' utility maximization and the post-tax real wages - and labour demand, which implies an increase in the rate of unemployment. In the longer run, however, employment tends to recover as real wages gradually adjust.

It can be seen from Figure 5 that, under wage rigidities, most GDP aggregates fall deeper than under flexible wages. Consequently, the fall in exports is also larger as the labour costs are now adjusting with a lag. The pattern of our results matches well the empirical findings of e.g. Blanchard and Perotti (2002) on the dynamic effects of tax changes on GDP, consumption and investment.

Figure 5 *Changes in expenditure aggregates under wage rigidities*



The larger fall in employment can also be seen from the contributions of income aggregates to GDP, shown in Figure 6. Since in the short run capital is fixed, the fall in employment causes a larger effect on GDP than under flexible wages. This can be seen from the income-side GDP aggregates in Figure 5, which show a larger negative contribution of primary factors on GDP than under perfect competition. The effects of the reform on demand aggregates in Figure 7 show that the wage rigidity makes the reform less beneficial for investment and aggravates the negative export effects.

Figure 6 Contributions of income aggregates on GDP in policy under wage rigidities

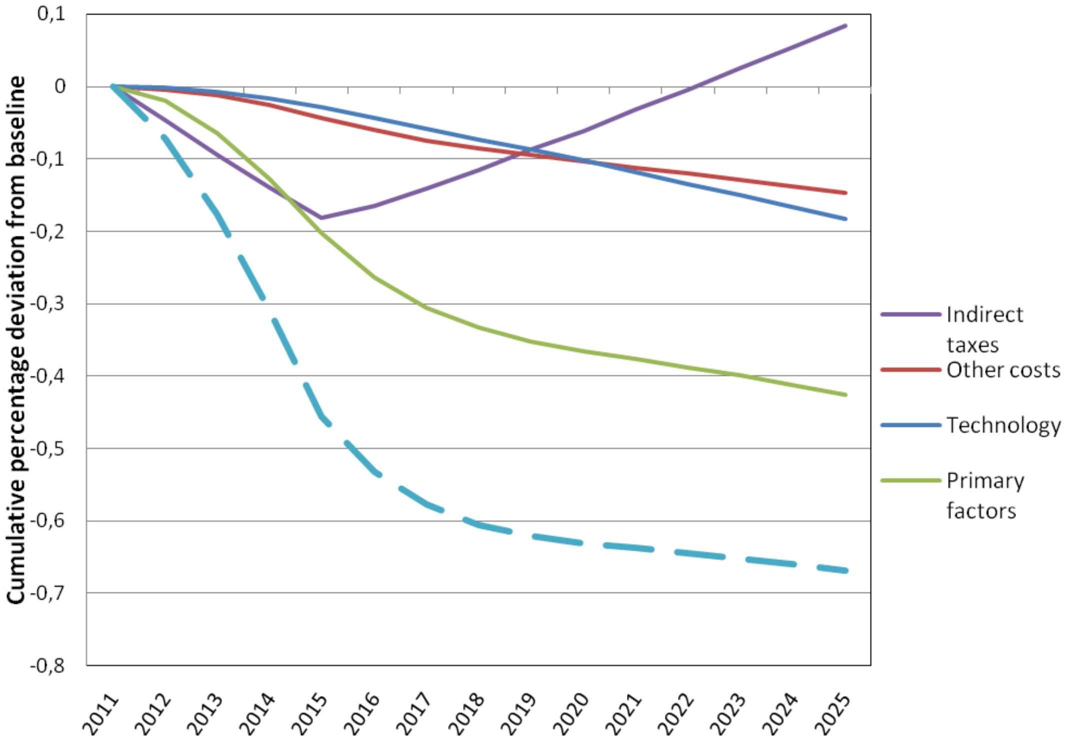
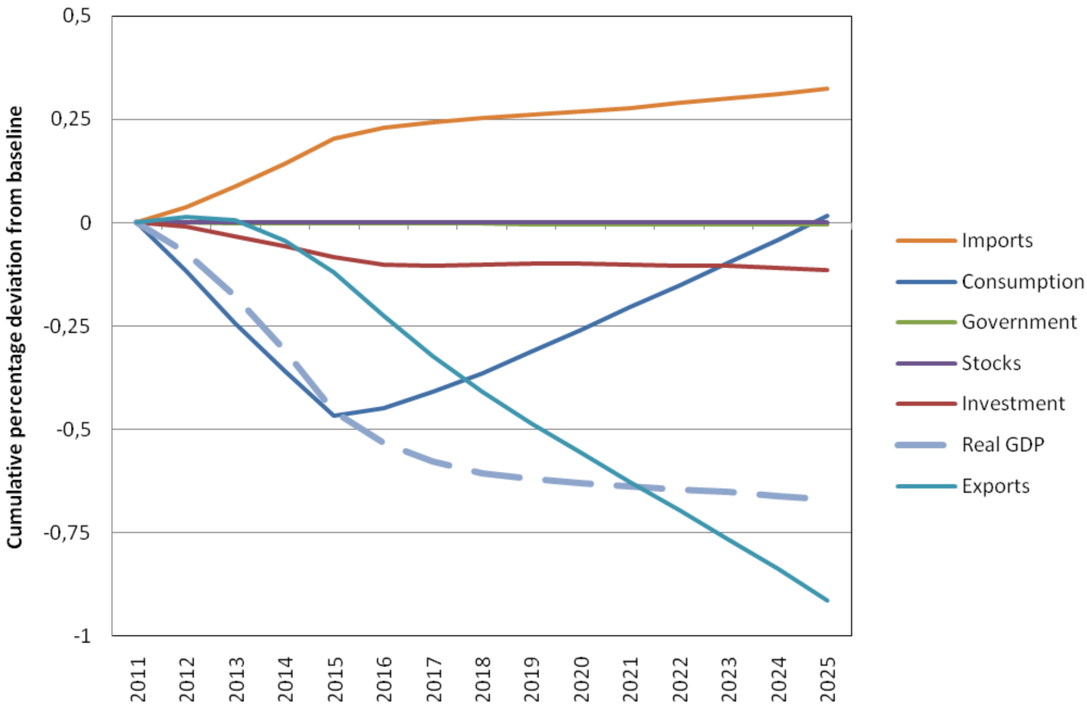


Figure 7 Contributions of expenditure aggregates on GDP in policy under wage rigidities



2.3.3 Distributional effects

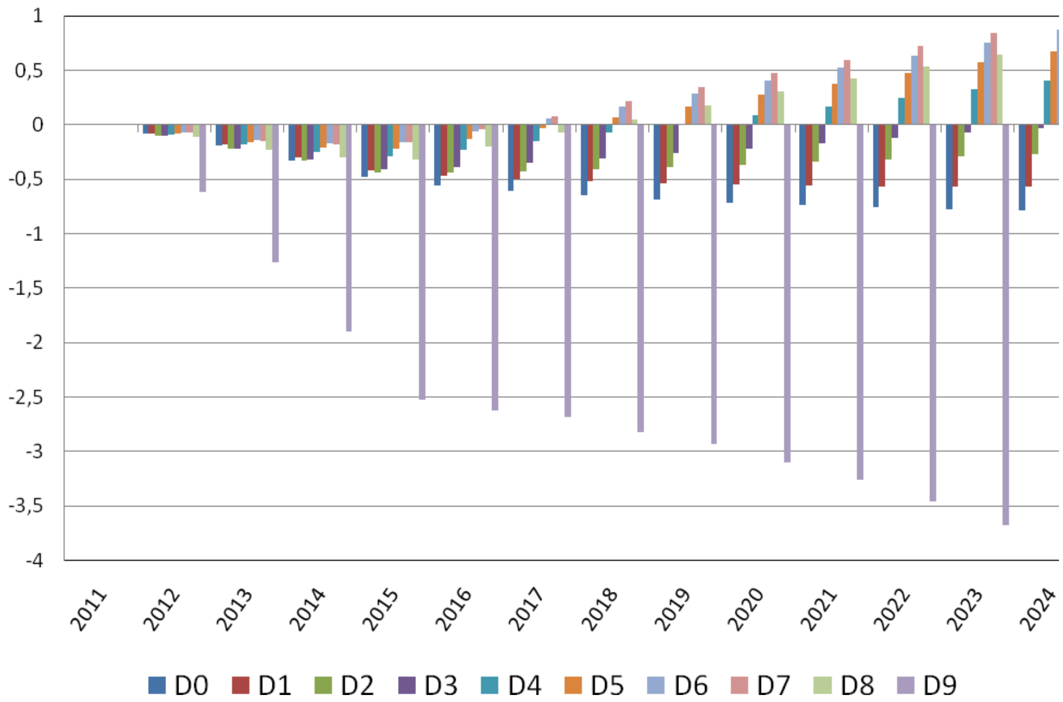
The tax reform proposal contains elements that can be expected to have distributional effects. Because of income tax progression, the higher–earning deciles should benefit relatively less from the tax cuts than the lowest income deciles. On the other hand, the share of labour income is much higher in the highest income deciles than in the lowest, whereas transfer income – age-related and social security – form the largest part of incomes in the lowest-income deciles.

The proposed lower overall taxation of capital incomes might be expected to benefit the highest-earning deciles. However, the incidence of increased consumption taxes is not necessarily clear a priori; there are elements, energy taxes, for example, where previous studies have found evidence of regressive effects, but as the increases also apply to many services, whose consumption shares in the higher earning deciles are higher than in the lowest deciles, one could also expect some opposite effects.

Here, we measure distributional effects in terms of equivalent variation. This is a broader measure than consumption-based measures alone, since it takes into account the effects of the proposal on labour supply as well as those on consumption and saving.

Figure 8 shows welfare effects under the assumption of wage flexibility as deviations from the baseline. A striking result is that the proposal would only have a marginal effect the welfare of the lowest and highest income deciles. In the longer run, the welfare of the higher earning deciles would improve, however. There is a natural explanation for this. Over the course of the decade, labour markets will become tighter as labour supply is projected to start to fall towards the end of the decade. This is reflected in real wages, whose rise benefits especially the higher income deciles. Employment is also improving in the short run in many of the middle-income deciles, as shown in Figures 10 and 11, and even in the long run, may be falling less than average.

Figure 8 Equivalent variation under flexible wages (deviation)



Conversely, the lower income deciles depend more on transfer incomes, and whether their incomes keep up with the general rise in purchasing power depends on the indexation of transfer incomes. Here, we assume that transfers are indexed to the consumer price index. Under this assumption, in Figure 10, we find that the lowest income deciles would eventually see its welfare decline. This is due to the high share of goods with high indirect tax content in their consumption baskets, which leads the price index of consumption for these particular deciles to rise more than the overall CPI does. Below, we study how the results would change if transfers were also indexed to real wages.

Figure 9 *Equivalent variation under wage rigidities (deviation)*

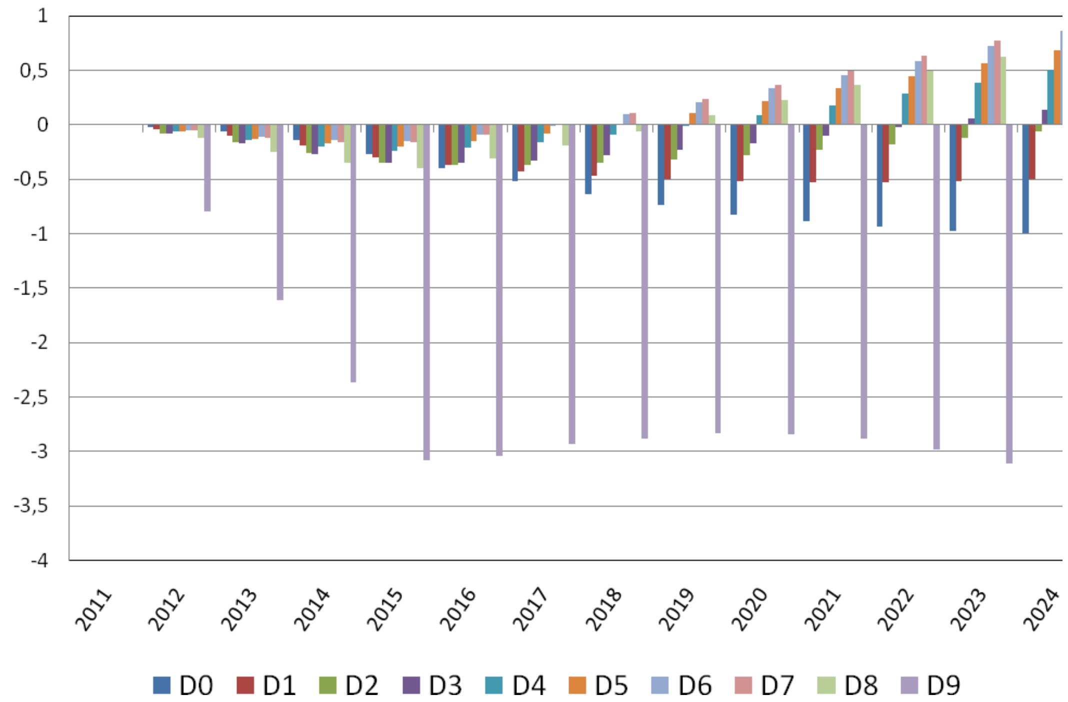


Figure 10 *Effects on employment under flexible wages*

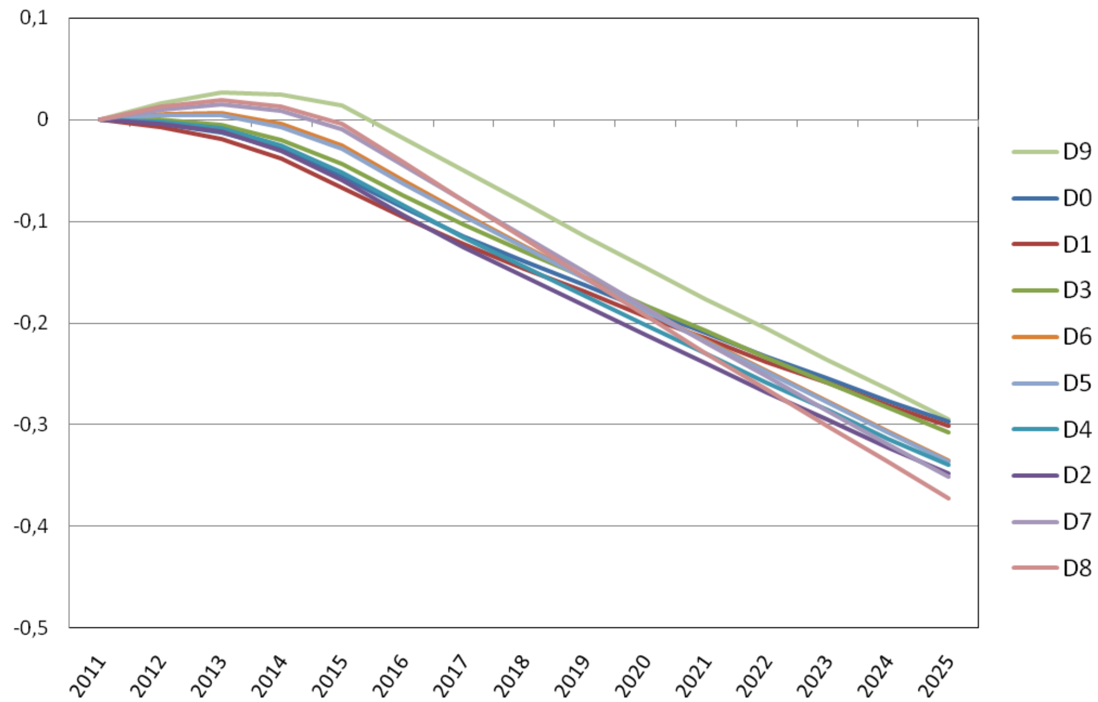
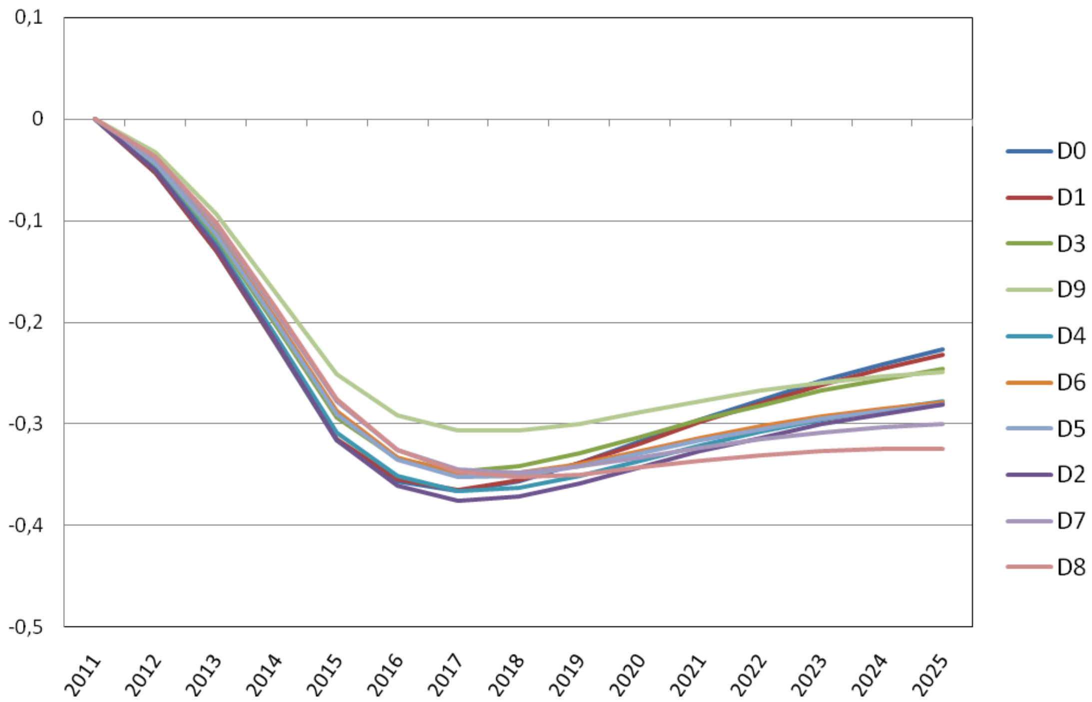


Figure 11 Effects on employment under wage rigidities



The indexation of transfer incomes can be seen as a genuine policy decision. Here, we show that indexation has a large impact on the overall effects of the reform. Figure 12 shows that with indexation of the benefits to both pre-tax real wages and the CPI, the cut in income taxes is not large enough to compensate for the higher consumption taxes. Consequently, there is a more pronounced fall in household demand, and only the positive effects of lower capital taxes remain. Figure 13, in turn, shows that the distributional effects of the reform also depend on indexation; with the alternative indexation scheme, the lowest-income deciles stand to lose from the reform from the outset, as their incomes would deteriorate in relative to wage-earners – who would be compensated with the cut in income taxes - at approximately the rate of real wage growth.

Figure 12 Macroeconomic effects with indexation to real wages and CPI (deviation)

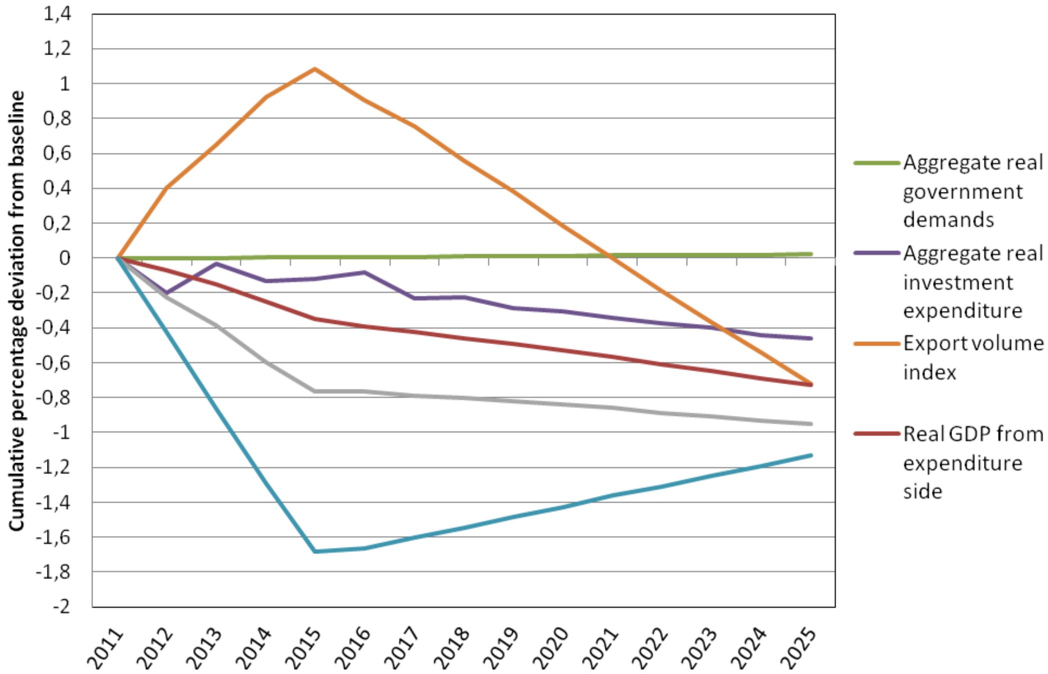


Figure 13 Equivalent variation with indexation to real wages and CPI (deviation)

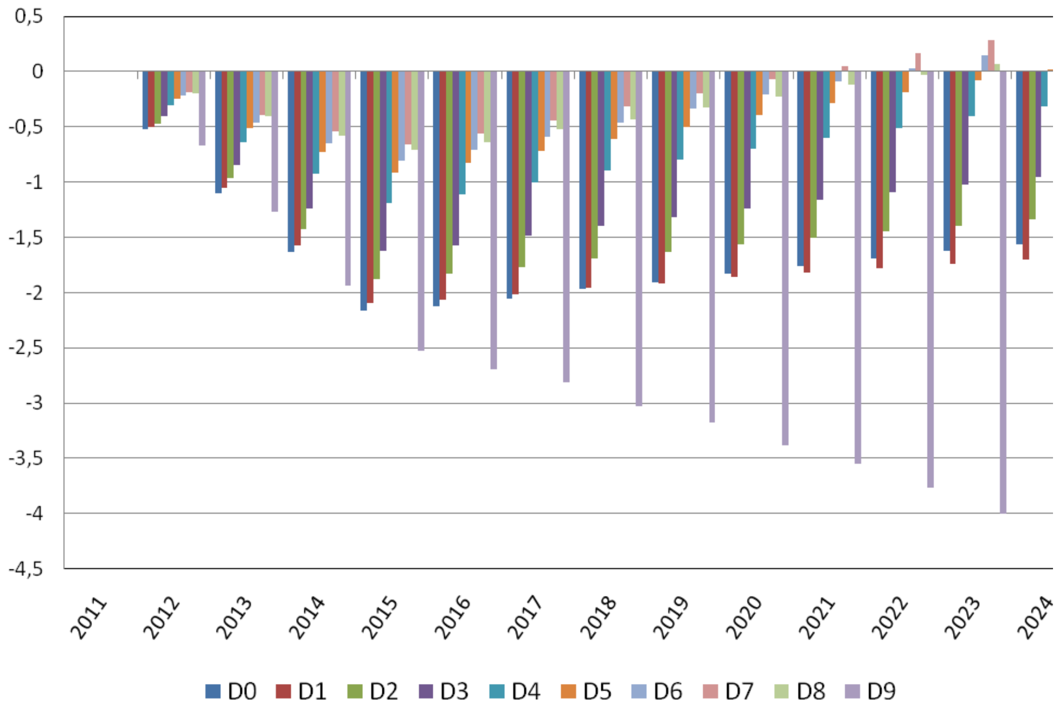
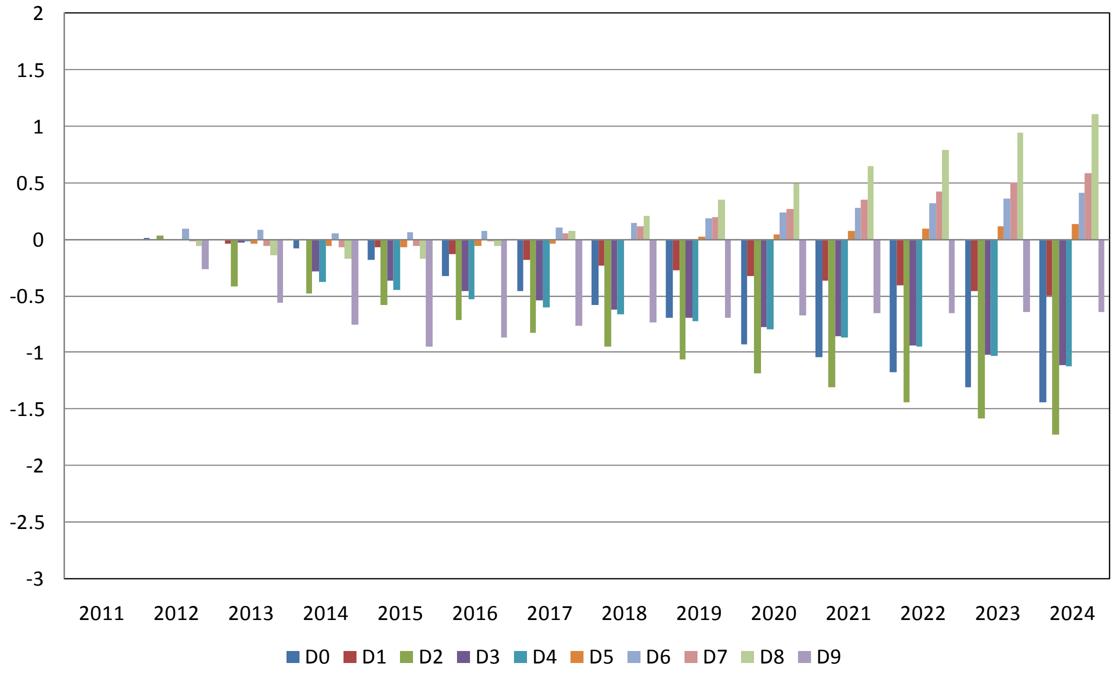


Figure 14 Equivalent variation with indexation to real wages and CPI, all income tax changes (deviations)



2.3.4 Sector effects

It has already been noted that the reform encourages investment by improving the returns to capital. Here, we consider the effects of the reform under two specifications. First, we evaluate the effects assuming a general fall in the capital income tax rate without taking into account the sector-specific effects of corporate taxes. Second, we allow for the effect of the corporate taxes on the perceived rate of return in each sector.

Industry responses to the tax structure changes depend on their relative labour intensity, as well as intermediate goods intensity, since the tax reform raises the tax on many commodities. Figure 15 shows our results on employment for industry aggregates, while Figure 16 shows the results on investment under the first specification. It is clear from the results that the reform has the effect of at least initially encouraging investment in the capital-intensive, exporting sectors. Increased investment also drives an increase in employment in these sectors. Many service sectors are also relatively capital intensive, benefitting from the reform.

Figure 15 Effects on employment (deviation)

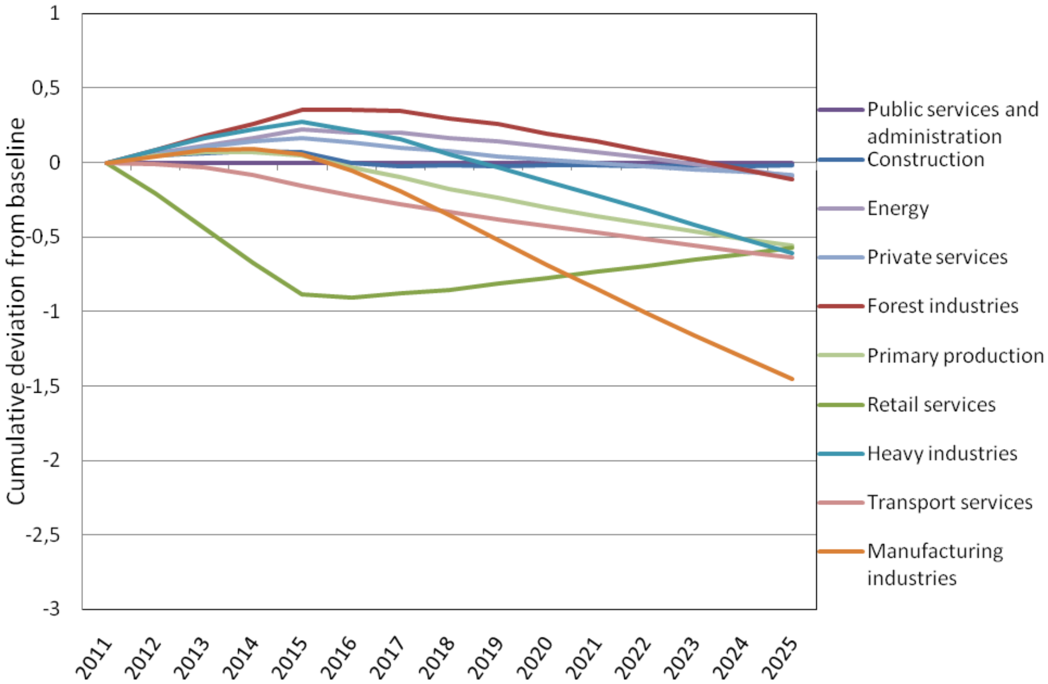
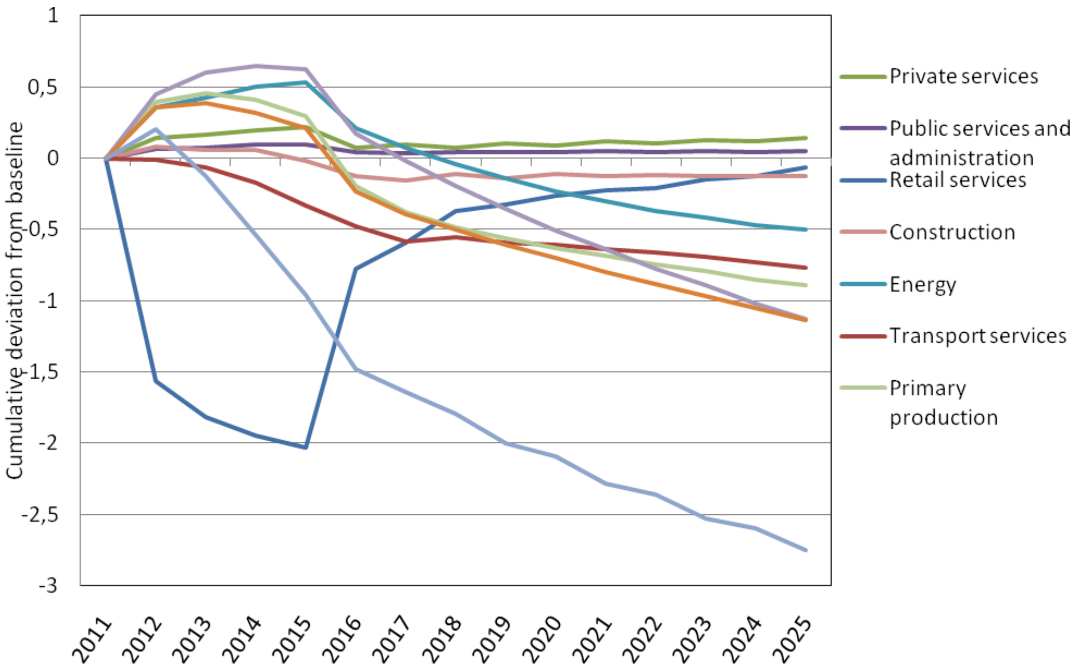


Figure 16 Effects on investment (deviation)



Figures 17 and 18 show investment and employment under the second specification. Investment increases markedly more in most sectors, but especially in the labour intensive manufacturing industries, which include, for example, the electronics industry.

Remarkably, under neither model specification does employment in the labour intensive industries increase permanently. We suspect that this may be an indication of a mismatch of skills, since, in the long run, labour supply increases only moderately or not at all in the deciles (from D4 upwards) that have a high share in the high-skill, industrial occupations. For example, only about 18 per cent of process workers, who constitute over 40 per cent of manufacturing industry employees, are represented in the three lowest income deciles, whereas their share is close to or above 10 per cent in all deciles from D4 to D8, whose employment is falling more in the long run than that of the lower income deciles. Nevertheless, in the short run this problem does not appear to be present, since the middle-to high income deciles' employment is increasing in the short run, and their labour supply even in the long run.

Figure 17 Effects on employment, sector-specific corporate taxes (deviation)

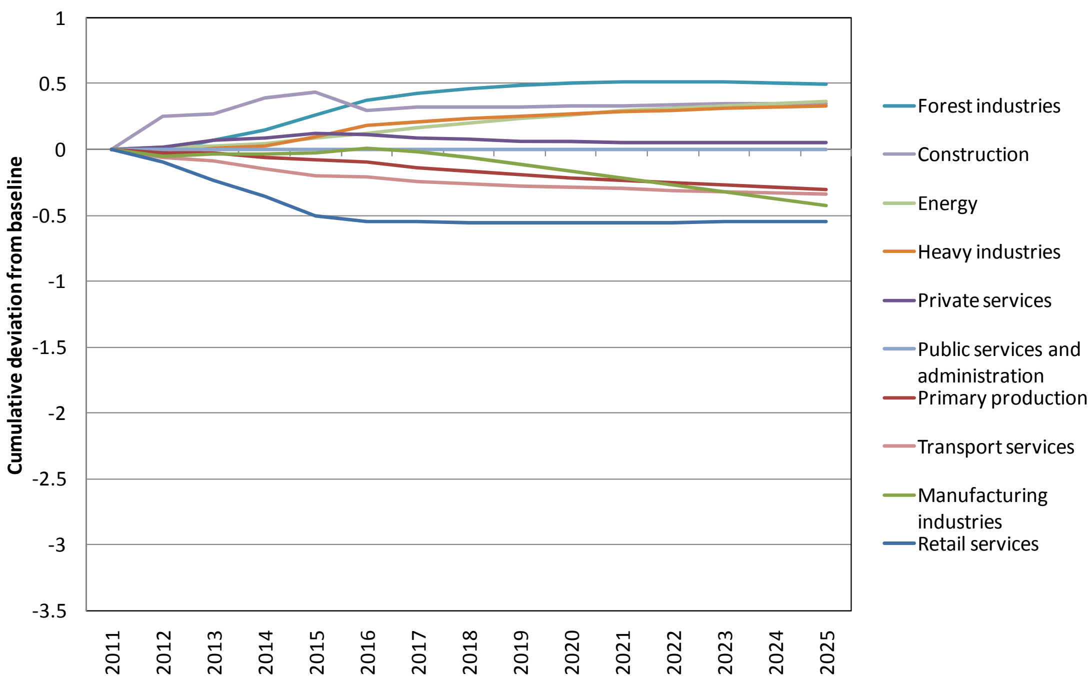
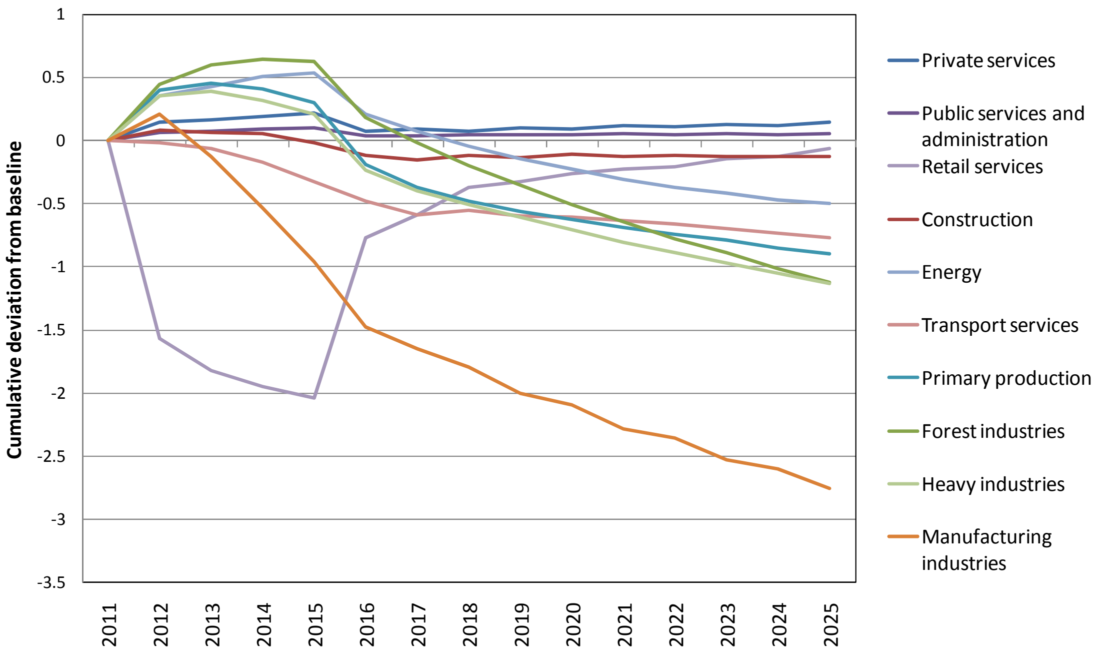


Figure 18 *Effects on investment, sector-specific corporate taxes (deviation)*



2.3.5 Effects on tax revenue and efficiency

In this section, we summarize the effects of our simulations from the points of view of the sustainability of public sector finances and the efficiency of the tax system. We measure efficiency by calculating the Marginal Cost of Funds for the scenarios studied above. As Dahlby (2008) points out, changes in even one tax rate can have effects on the collection of other taxes due to the interdependency of different tax types. The advantage of MCF is that it summarizes the overall effects from the welfare point of view taking into account the effects of these interactions. We define the marginal cost of funds as:

$$MCF = \frac{-\mathrm{EV}}{\Delta R} = \frac{-[e(p^0, U^0) - e(p^0, U^1)]}{\Delta R} \qquad (19)$$

where EV is the equivalent variation in welfare. It measures the monetary value of the loss in utility resulting from price changes due to the new tax policy. Equivalent variation is calculated with the help of the expenditure function e(p,U), in which p^0 indicates the price of products at the pre-tax change situation and U^0 and U^1 the level of consumer's utility at the pre-tax change and post-tax change situations respectively.

Under this definition, the MCF for a pure tax increase would be greater than one, indicating that the collection of additional revenue involves a welfare cost. For a tax reform, however, it is possible that MCF < 1, which implies that the reform is welfare improving. It is also possible that MCF is negative, whence it needs to be further specified whether the welfare effect is a Pareto improvement (positive welfare effect and positive change in tax revenue) or a deterioration (negative welfare effect with negative change in tax revenue).

Figure 19 shows the changes in nominal tax revenue aggregates in millions of Euros in our central scenario with flexible wages and full indexation of social security and age benefits. In nominal terms, the reform starts with very near revenue neutrality, with increased commodity tax revenues compensating for the loss in income tax revenue. Over time, as structures adjust, the government starts running a surplus (negative deficit). Thus the reform would appear unbalanced in the long run from the point of view of real revenue and deficit.

But there are other considerations. Since the economy is growing, it is not necessarily the contribution to surplus that matters, but the sustainability of public sector finances. This is studied in Figures 20 to 22, which show the deviation in net tax revenues – which is positive in our central case, showing the reform is actually revenue gaining even – under different specifications.

A key finding of the study is presented in Figures 20 to 22. We find that the MCF for the reform would initially be fairly high, which is to be expected since it takes time for capital stocks to adjust. Eventually, however, the MCF would settle to around 0.5. This indicates that the reform would be welfare improving in the long run. The gains are undermined in the alternative transfer indexation scheme, since consumers' incomes fall more on the average. Finally, under the sector-specific corporate tax cuts, welfare gains are also evident, and they are also achieved sooner than in the main case.

The figures also report the change in the EU sustainability indices in absolute terms compared to the baseline; a negative value indicates the index obtains a lower value than in the baseline, meaning overall taxation could be lowered while still reaching the same debt to GDP ratio target as in the baseline. The results then suggest that, in terms of sustainability, the reform is indeed neutral or even slightly sustainability-improving in our central case.

Figure 19 Changes in tax revenue (Mio euro)

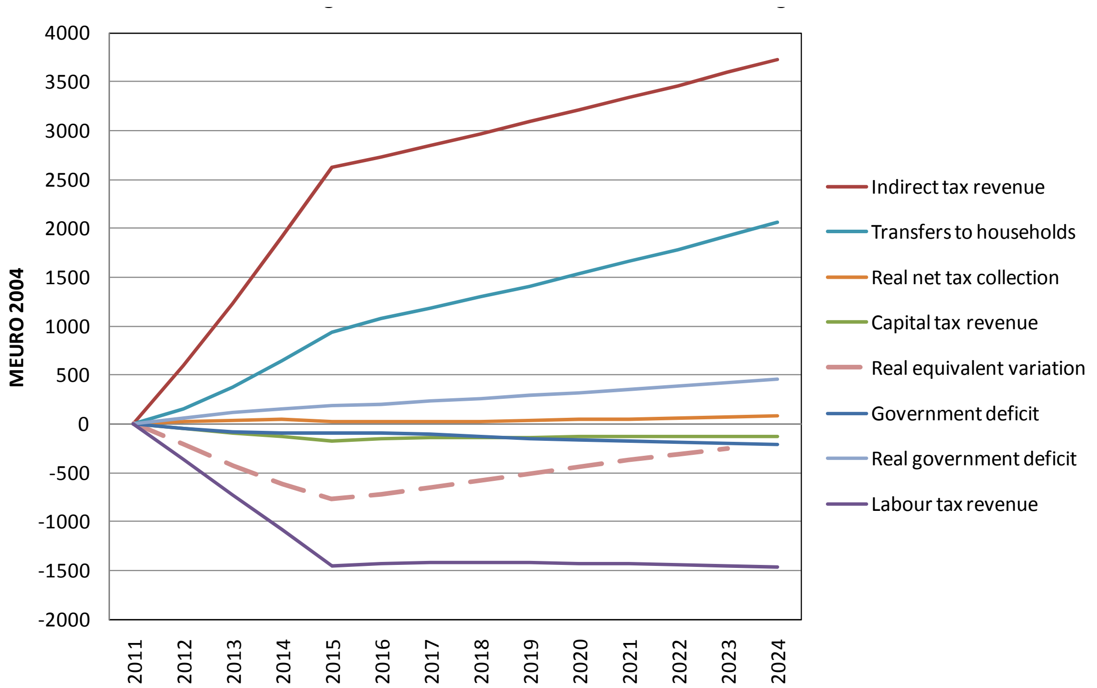


Figure 20 Effects on sustainability and efficiency

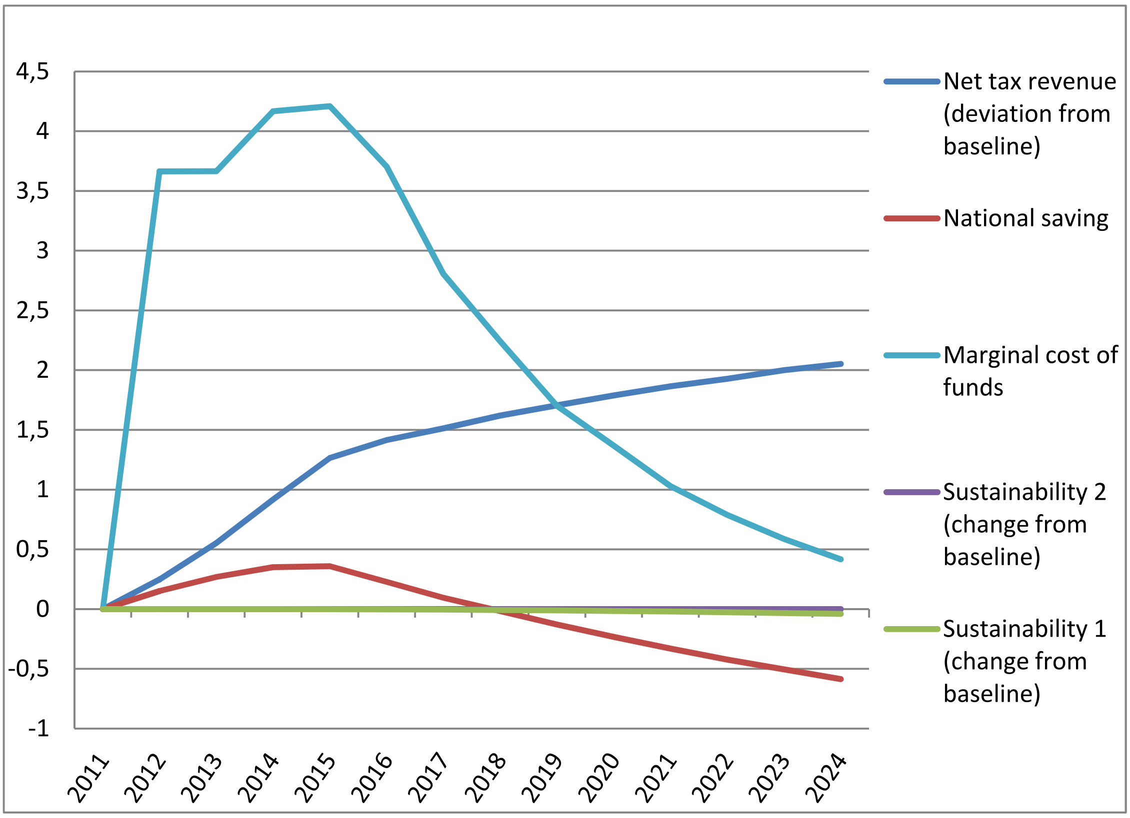


Figure 21 Effects on sustainability and efficiency, sector-specific corporate taxes (deviation)

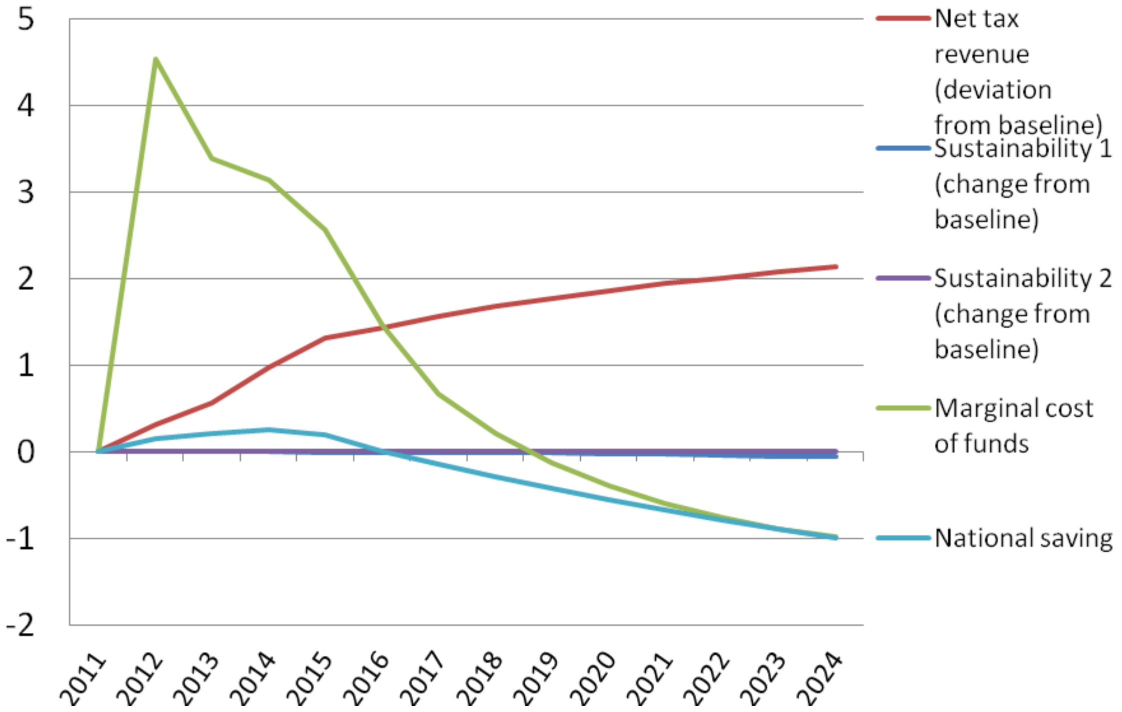
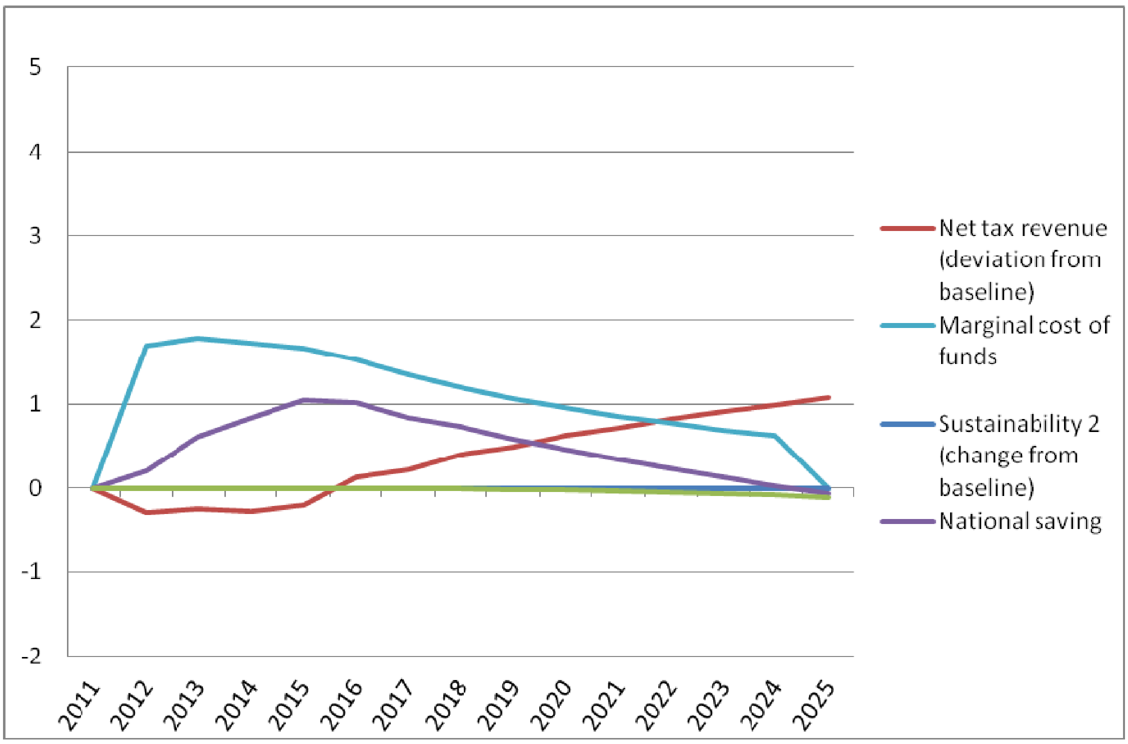


Figure 22 Effects on sustainability and efficiency with real wage and CPI-based indexation of transfers



2.4 Conclusions

In the current study, we have examined the effects of the recent tax reform proposal of the Tax Committee on the economy as a whole and on the efficiency of taxation in particular. We have also studied the proposal's distributional and sector effects.

Our central findings are that while the proposed income tax cuts initially boost labour supply in some deciles, over time, aggregate labour supply is likely to fall. This effect is found in many other studies as well and is due to the positive income effect of the tax cut. Because of the fall in labour supply, GDP is also likely to fall. We find that the proposal would be likely to stimulate exports, investment in the short run, but in the long run, as consumption picks up, the effect on exports would be negative. The proposal would also initially reduce income differences, but in the long run, the distributional effects depend on the indexation of social security benefits and pensions, as well as the extent of income tax cuts on these incomes. In terms of efficiency, we find the proposal welfare improving in our central scenario, which assumes flexible real wages. In accord with many other studies, we also find that wage rigidities would undermine the efficiency gains in the short run.

In some respects, our study also demonstrates the ambiguity in defining a tax reform. As in many other studies, we have assumed that public expenditure on commodities and investment does not respond to the real changes caused by the tax reform. Even so, there are many types of public expenditure that do depend on these changes, and consequently we find that a reform intended to be neutral does have effects on the government's net tax revenues and its deficit over time. However, we show that on impact, the proposal is very nearly revenue neutral, and, moreover, it is close to neutral in the long run in the sense that it has only a small impact on the sustainability of a long-term debt target.

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3. Population ageing in a small open economy – some policy experiments with a tractable general equilibrium model[6]

Juha Kilponen – Helvi Kinnunen – Antti Ripatti

3.1 Introduction

Populations in most of the industrialized countries are ageing. Demographic patterns are especially pronounced in some European economies where old-age dependency ratio are set to rise considerably. The key factors behind this trend are a slowdown of population growth and a substantial increase in longevity. Many European countries have begun to prepare for demographic change. In many European countries where tax rates are already at very high levels, an additional fiscal burden on labour could have detrimental effects on future economic performance.

One of the main ideas for resolving the issue has been to design pension reforms that increase incentives to work longer and/or to cut pension benefits. One prominent example from Europe is Finland, where the pension reform effective from the start of 2005 introduced a flexible retirement age of from 63 to 68. Under the latest pension reform, the pension level is now linked more explicitly than before to exit age and thus with to contributions made by the insured. This is expected to increase incentives to work longer. Furthermore, starting from 2009, changes in life expectancy will effect pension levels. In addition, pension indexation has been changed so that all pensions will be indexed using a weight of 0.8 for living costs and 0.2 for wages, in contrast to the earlier `midway index' applied up to age 65. This will contribute to some erosion of the value of pensions compared to wage level in the future. The latter reforms are clearly attempts to moderate the fiscal impact of growing pension expenditures.

In this paper, we develop a tractable dynamic general equilibrium macro-economic model that allows us to account for demographic transition. The model features dynamic optimization of a small open economy with an internationally given real interest rate and a non-stochastic balanced growth path determined by labour saving technological development and population growth. Optimal

[6] This is based on the Bank of Finland Discussion Paper Juha Kilponen - Helvi Kinnunen - Antti Ripatti: Population ageing in a small open economy - some policy experiments with a tractable general equilibrium model, Nro 28/2006, Bank of Finland.

consumption and labour supply decisions are based on Gertler's (1999) tractable overlapping generation model, extended for distortionary taxes and time-varying retirement and death probabilities[7]. Pensions are conditioned on aggregate wage level and on demographic trend, and the model features a partially funded pension system. The funded part of the pension system is considered contractual saving (assets accumulated by the pension fund) and the PAYG part as a transfer from workers to pensioners. These transfers are financed by collecting pension contributions from firms and workers. Finally, we quantify the uncertainty associated with demographic projections, by allowing for stochastic variation in the key variables driving demographic trends.

The results of simulations highlight the key role played by feedback effects from taxation in the assessment of economic costs of ageing. When the responses of labour supply, real wages, and hence private consumption, to higher taxation are consistently accounted for, the economy settles at a level of taxation clearly above that generally estimated in mechanical sustainability calculations. Even if the effective retirement age were to increase as expected, the burden from pension payments alone would cause the tax rate to rise to a level above that witnessed in the worst years of Finland's recession of the mid-1990s. Results from stochastic simulations support this view, by showing that a lengthening of working time has only a minor alleviating impact on the fiscal burden of ageing: Only a small fraction of the stochastic variation in an endogenously determined income tax rate is explained by the stochastic variation in the length of working time. Finally, if the pension replacement rate falls, as seems likely under the current pension regime, there would be a much smaller increase in taxation in response to rising dependency ratio. The average decline in the level of pensions relative to wage developments, however, raises a concern that the falling purchasing power of pensions relative to wage developments will exert pressure on other social security schemes. The current pension scheme, which appears to be financially sustainable, may thus in practice generate costs to local and central government in the form of higher expenditures on income support and other benefits.

The rest of the paper is organized as follows. 4. 2 introduces the model, including a description of the pension system. Sections 4.4 – 4.6 discuss the results from various policy experiments including a sensitivity analysis and stochastic simulations. Section 4.7 concludes.

[7] Keuschnigg and Keuschnigg (2004), Ferrero (2005), Roeger (2005), Kara and Thadden (2006), Fujivara and Teranish (2006), and Grafenhofer, Jaag, Keuschnigg and Keuschnigg (2006) develop the Gertler (1999) model further and study different aspects of population ageing in their models.

3.2 The model

3.2.1 General features

The model developed in this paper features dynamic optimization of a small open economy with an internationally given real interest rate and non-stochastic balanced growth path. On the balanced growth path, economic growth is determined by exogenously given growth of labour-saving technology and population.

Households' saving decisions, and hence accumulation of financial assets, are influenced by households' desire to smooth consumption over time. Individuals are expected to have finite lives consisting of two distinct periods. Following Gertler (1999), we label the households living in these two different periods `workers' and `retirees'.

The likelihood that a worker will lose part of his labour income at retirement, induces her to discount the future income stream at a higher rate than otherwise. This reduces consumption and increases saving. In this sense, workers save for a rainy day and for retirement.[8] The planning horizon of pensioners is shorter than that of workers due to the periodic probability of death. Therefore pensioners' propensity to consume out of wealth is greater than that of the working-age population.

In order to capture changing labour supply incentives of the elderly, we assume that `retirees' participate in the labour markets. However, compared to workers, their labour efficiency is lower. Lower labour efficiency can capture issues such as part-time work and possibly lower productivity. A more general, elastic labour supply allows demographic change to feed into adjustment of capital and investment via the capital-labour substitution effect.

Individuals receive transfers from both the central government and pension funds. However, in order to maintain analytical tractability, pensions are related to the prevailing aggregate wage level, and not to individual characteristics[9]. The

[8] This view is generally consistent with the study of Gourinchas and Parker (2002), who find that empirically observed saving patterns accord with forward-looking optimizing behaviour in a life-cycle setup with income uncertainty. Their study suggests that the precautionary saving motive in early life implies that between 60 and 70% of non-pension wealth is due to precautionary saving.

[9] In contrast to large scale overlapping generations models, such as Auerbach-Kottlikoff (1987), we do not follow individual cohorts within the two age groups. This limits our ability to model the demographic change and pension system in a very detailed manner. We also need to abstract from many other potential sources of heterogeneity in consumption and labour supply behaviour, such as differing educational levels. However, we can still specify the retirement and

pension system is characterised as partially funded. We consider the funded part of the pension system contractual saving (assets accumulated by the pension fund) and the PAYG part as a transfer from workers to pensioners. These transfers are financed by collecting pension contributions from firms and workers as noted above.

The model is closed by fiscal rules. Given that we distinguish between central government and the pension fund, one fiscal rule determines the pension fund's long-term net lending rate, while the other determines the central government `debt ratio'. Supply side (production structure) is based on CES production technology with factor augmentation in the underlying technological progresses and nominal and real rigidities.

3.2.2 Demographics

Consumers are assumed to be born as workers. Conditional on being a worker in the current period, the probability of remaining one in the next period is ω_t, while the probability of retiring is $1-\omega_t$. These transition probabilities are independent of individuals' employment tenure, so that the average tenure of working is $\frac{1}{1-\omega_t}$. In order to allow for a non-stationary demographic structure, we allow for time varying probabilities. Once an individual has retired she faces a periodic probability of death of $(1-\gamma_t)$. Given that the survival probability γ_t is assumed to be independent of retirement tenure, but that it may depend on calendar time, the average retirement period at each point of time is $\frac{1}{1-\gamma_t}$. Allowing for time variation in the retirement and death probabilities enables us to generate demographic `shocks' that feed into the dependency ratio gradually rather than instantly.

Let N_t^w denote the stock of workers alive at time t. We then assume that $\left(1-\omega_{t+1}+n_{t+1}^w\right)$ new workers are born at t+1. This implies that we can set worker population to grow at some exogenous gross growth rate of $\hat{N}_{t+1}^w$

$$N_{t+1}^w = (1-\omega_{t+1}+n_{t+1}^w)N_t^w + \omega_{t+1}N_t^w = \hat{N}_{t+1}^w N_t^w \tag{1}$$

death probabilities, as well as the growth rate of working-age population, in such a way that demographic transition can be captured with reasonable accuracy at the aggregate level. Similarly, linking pensions to demographics, we can roughly mimic the associated trends in pensions and public expenditures.

where $\hat{N}^w_{t+1} \equiv 1 + n^w_{t+1}$. Given age-independent probabilities of retirement and death and that cohorts are large, the retiree population (N^r_t) evolves according to

$$N^r_{t+1} = (1 - \omega_{t+1})N^w_t + \gamma_{t+1} N^r_t \tag{2}$$

where N^r_t refers to the stock of retirees population at time t. With some manipulation, it is shown that the retiree-to-worker ratio, $\varphi_t = \frac{N^r_t}{N^w_t}$, evolves according to

$$\varphi_t \equiv \frac{N^r_t}{N^w_t} = \frac{1-\omega_t}{\hat{N}^w_t} + \gamma_t \frac{\varphi_{t-1}}{\hat{N}^w_t}: \tag{3}$$

Defining the stock of whole population as $N_t = N^w_t + N^r_t$, we can express the growth rate for the whole population as a function of retiree to worker ratio and growth rate of working age population as follows

$$\hat{N}_t = \frac{(1+\varphi_t)N^w_t}{(1+\varphi_{t-1})N^w_{t-1}} = \frac{(1+\varphi_t)}{(1+\varphi_{t-1})}\hat{N}^w_t \tag{4}$$

In the steady state the demographic change has ended, so that

$$\hat{N} = \hat{N}^w = \hat{N}^r \tag{5}$$

$$\varphi = \frac{1-\omega}{\hat{N} - \gamma} \tag{6}$$

3.2.3 Households

3.2.3.1 Preferences

A household's preferences are expressed recursively using the constant elasticity aggregator

$$V_t = [\{u(C_t, l_t)\}^{\rho_c} + \beta\{E_t(V_{t+1})^{\mu}\}^{\frac{\rho_c}{\mu}}]^{\frac{1}{\rho_c}}. \tag{7}$$

V_t is the value function, and β gives the subjective time preference. The parameter $\rho_c < 1$ captures intertemporal substitution. A special case of $\mu = 1$, applied here, corresponds to a type of risk neutrality where agents are indifferent regarding risk but retain a non-trivial preference for the time at which consumption occurs (cf. Farmer, 1990)[10]. This special case is analytically tractable, since it generates linear decision rules even with (idiosyncratic) risk to income, asset return and length of life. In addition to risk neutrality and a recursive structure of preferences, we assume that individuals enjoy utility from consumption, C_t , as well as leisure, $(1-l_t)$, according to the utility functional

$$u(C_t, l_t) = C_t^v (1-l_t)^{1-v}. \tag{8}$$

where v is the elasticity of period utility with respect to consumption.

Taking into account the two distinct periods of life, as well as retiring and death probabilities, the preferences of a household can be summarized as

$$V_t^z = \left\{ \left[\left(C_t^z\right)^v (1-l_t^z)^{1-v} \right]^{\rho_c} + \beta^z [E_t(V_{t+1} \mid z)]^{\rho_c} \right\}^{\frac{1}{\rho_c}}$$

where

$$E_t(V_{t+1} \mid w) = \omega_t V_{t+1}^w + (1-\omega_t) V_{t+1}^r, \; \beta^w = \beta \tag{9}$$

$$E_t(V_{t+1} \mid r) = V_{t+1}^r, \; \beta_t^r = \beta \gamma_t. \tag{10}$$

and where $z = w, r$ indicates whether the individual is a worker or retiree respectively. The willingness to smooth consumption over time implies a finite (constant) inter-temporal elasticity of substitution $\sigma = 1/(1-\rho_c)$. The retirees effective discount factor β^r is adjusted to take into account the periodic probability of death. We assume a perfect annuities market in order to eliminate the impact of uncertainty about time of death: A retiree's remaining wealth at death is invested in a mutual fund, which invests it in the available financial assets in each period of time. Those surviving to the following period each receive a return that is proportional to his contribution to the fund. For instance, if R_t is the gross return per unit invested by the fund, the gross return for a surviving retirees is at time t R_t / γ_t.

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[10] Assumption of risk-neutrality is important. For instance, analysis of welfare effects of social security reforms are importantly affected by the treatment of risk. A mandatory social security system imposes an implicit tax on households, so that there is a reduction in expected life-cycle income (due to social security contributions). However, if the social security system reduces the variance of life-cycle income by pooling the income risk between young and old generation, there is potentially a tradeoff between a reduction in expected life-cycle income and the variability: The reduction of welfare due to mandatory social security would then be lower for risk-averse households than for risk-neutral ones.

Workers, in turn, face the risk of decline in wage income at retirement. However, since an individual's preferences are over the mean of the next period's value function, only a desire the smooth consumption over time will affect the consumption pattern in the face of idiosyncratic income risk. Thus a worker simply forms a certainty equivalent of his random utility, as shown in equation (9).

3.2.3.2 Retirees

A retiree born at time j and retiring at time k, and who survives at least until t+1, solves the maximization problem

$$\max_{C_t^{rjk}, l_t^{rjk}} V_t^{rjk} = \left\{ \left[\left(C_t^{rjk}\right)^v (1 - l_t^{rjk})^{1-v} \right]^{\rho_c} + \beta\gamma_t [E_t(V_{t+1}^{rjk})]^{\rho_c} \right\}^{\frac{1}{\rho_c}} \tag{11}$$

s.t.

$$A_{t+1}^{rjk} = \frac{1}{\gamma_t} R_t A_t^{rjk} + W_t(1 - \mathrm{t}_t)\xi l_t^{rjk} + \mathbf{T}_t^{rjk} - P_t^c C_t^{rjk} \tag{12}$$

where R_t denotes after-tax gross rate of return on financial assets A_t^{rjk} , $\mathbf{T}_t^{rjk}$ denotes pensions, and $\xi < 1$ is the labour efficiency of retirees with respect to workers. P_t^c is a price index of consumption, to be determined later. t_t is the total labour income tax rate including pension contribution rate, t_t^{WP}, to be discussed later. From the first order condition for labour, we first derive a standard labour supply condition

$$1 - l_t^{rjk} = \frac{1-v}{v} \frac{P_t^c C_t^{rjk}}{(1 - \mathrm{t}_t) W_t \xi} \tag{13}$$

Solving the retiree's maximization problem with respect to consumption, using (13)) and then aggregating over retirees results into following aggregate consumption equation

$$P_t^c C_t^r = \varepsilon_t \pi_t [R_t A_t^r + \mathbf{H}_t^r + \mathbf{S}_t^r]. \tag{14}$$

$\mathbf{H}_t^r$ and $\mathbf{S}_t^r$ denote discounted after-tax values of labour income and pensions, and $\varepsilon_t\pi_t$ is retirees marginal propensity to consume out of wealth. More specifically

$$\mathbf{H}_t^r = (1 - \mathrm{t}_t) W_t \xi L_t^r + \frac{\mathbf{H}_{t+1}^r}{\hat{N}_{t+1}^r R_{t+1} / \gamma_{t+1}} \tag{15}$$

$$\mathbf{S}_t^r = \mathbf{T}_t^r + \frac{\mathbf{S}_{t+1}^r}{\hat{N}_{t+1}^r R_{t+1} / \gamma_{t+1}}. \tag{16}$$

Since total social security payments (pensions) are distributed equally among retirees, the gross growth rate of retirees $\hat{N}_{t+1}^r$ enters into the discount factor. The discount factor for human wealth is similarly augmented by $\hat{N}_{t+1}^r$. A retiree's marginal propensity to consume out of wealth $\varepsilon_t \pi_t$ evolves according to the following non-linear difference equation

$$\varepsilon_t \pi_t = 1 - \left(\frac{W_t / P_t^c}{W_{t+1} / P_{t+1}^c} \frac{(1-\mathrm{t}_t)}{(1-\mathrm{t}_{t+1})} \right)^{\frac{(1-\nu)\rho_c}{1-\rho_c}} \beta^{\frac{1}{1-\rho_c}} \left(\frac{R_{t+1}}{\hat{P}_{t+1}^c} \frac{\gamma_t}{\gamma_{t+1}} \right)^{\frac{\rho_c}{1-\rho_c}} \frac{\varepsilon_t \pi_t \gamma}{\varepsilon_{t+1} \pi} \tag{17}$$

where $\hat{P}_{t+1}^c \equiv P_{t+1}^c / P_t^c$. A retiree's marginal propensity to consume varies with the real interest rate $R_{t+1} / \hat{P}_{t+1}^c$ as well as with expected changes in real net wage income. Due to the fact that survival probability can vary over calendar time, it influences on retiree's effective discount rate and introduces additional dynamics into the marginal propensity to consume equation.

As in the standard Yaari (1965) and Blanchard (1985) models, likelihood of death ($1-\gamma_t$) in (17) raises the retirees' marginal propensity to consume. This can be seen easily by considering a limiting case of logarithmic preferences ($\sigma \to 1$) and when survival probability is constant. In this case

$$\varepsilon\pi = 1 - \beta\gamma \tag{18}$$

3.2.3.3 Workers

As regards workers, the decision problem for the worker born at time s, is

$$\max_{C_t^{ws}, l_t^{ws}} V_t^{ws} = \left\{ [(C_t^{ws})^{\nu} (1 - l_t^{ws})^{1-\nu}]^{\rho_c} + \beta [E_t (V_{t+1}^{ws})]^{\rho_c} \right\}^{\frac{1}{\rho_c}} \tag{19}$$

s.t.

$$A_{t+1}^{ws} = R_t A_t^{ws} + (1-\mathrm{t}_t) W_t l_t^{ws} + \mathbf{T}_t^{ws} - P_t^c C_t^{ws} \tag{20}$$

$\mathbf{T}_t^{ws}$ denotes financial transfers to working age and t_t is the total labour income tax rate. The first order condition for labour yields standard labour supply condition

$$1 - l_t^{ws} = \frac{\frac{1-\nu}{\nu} P_t^c C_t^{ws}}{(1 - \mathrm{t}_t) W_t} \tag{21}$$

Inter-temporal maximization in turn gives rise to a fairly complicated Euler equation, but again the workers' consumption plan aggregates to

$$P_t^c C_t^w = \pi_t [R_t A_t^w + \mathbf{H}_t^w + \mathbf{S}_t^w]. \tag{22}$$

π_t is a worker's marginal propensity to consume, while $\mathbf{H}_t^w$ and $\mathbf{S}_t^w$ denote her human and social security wealth, respectively. Marginal propensity to consume out of wealth is a non-linear first order difference equation

$$\pi_t = 1 - \left(\frac{(1 - \mathrm{t}_t) W_t / P_t^c}{W_{t+1} / P_{t+1}^c} \right)^{\frac{(1-\nu)\rho_c}{1-\rho_c}} \beta^{\frac{1}{1-\rho_c}} \left(\frac{\Omega_{t+1} R_{t+1}}{\hat{P}_{t+1}^c} \right)^{\frac{\rho_c}{1-\rho_c}} \frac{\pi_t}{\pi_{t+1}} \tag{23}$$

where Ω_{t+1} is the factor that weights the gross real return $R_{t+1}/\widehat{P_{t+1}^c}$. This factor evolves according to

$$\Omega_{t+1} = \left(\frac{1}{1 - \mathrm{t}_t} \right)^{1-\nu} [\omega_t + (1 - \omega_t) \varepsilon_{t+1}^{-\frac{1-\rho_c}{\rho_c}} \left(\frac{1}{\xi} \right)^{1-\nu}] \tag{24}$$

$\varepsilon_{t+1} > 1$ is the ratio of a retiree's marginal propensity to consume to that of a worker. The enlarged discount rate due to the presence of $\Omega_{t+1} > 1$ in the denominator of (25) - (26) means that workers value human wealth and social security *less* than in the infinite horizon case. This in turn tends reduce worker's consumption and increase saving. Importantly, notice also that distortionary taxes increase the workers' discount factor.

$\mathbf{H}_t^w$ in (22) is a discounted sum of worker's wage bill (in net terms) and $\mathbf{S}_t^w$ is the sum across workers alive at t of the capitalized value of social security (in net terms). Both of these measures take into account of corresponding discounted values at the time of retirement. Formally,

$$\mathbf{H}_t^w = \frac{\omega_t \left(\frac{1}{1-\mathrm{t}_{t+1}}\right)^{1-\upsilon} \mathbf{H}_{t+1}^w}{R_{t+1}\Omega_{t+1}\hat{N}_{t+1}^w} + (1-\mathrm{t}_t)W_t L_t^w + \frac{(1-\omega_t)(\varepsilon_{t+1})^{-\frac{1-\rho_C}{\rho_C}}\left(\frac{1}{\xi(1-\mathrm{t}_{t+1})}\right)^{1-\upsilon}\varphi_{t+1}^{-1}\mathbf{H}_{t+1}^{r(t+1)}}{R_{t+1}\Omega_{t+1}\hat{N}_{t+1}^r} \tag{24}$$

$$\mathbf{S}_t^w = \mathbf{T}_t^w + \frac{\omega_t \left(\frac{1}{(1-\mathrm{t}_{t+1})}\right)^{1-\upsilon} \mathbf{S}_{t+1}^w}{R_{t+1}\Omega_{t+1}\hat{N}_{t+1}^w} + \frac{(1-\omega_t)(\varepsilon_{t+1})^{-\frac{1-\rho}{\rho}}\left(\frac{1}{\xi(1-\mathrm{t}_{t+1})}\right)^{1-\upsilon}\varphi_{t+1}^{-1}\mathbf{S}_{t+1}^{r(t+1)}}{R_{t+1}\Omega_{t+1}\hat{N}_{t+1}^r} \tag{25}$$

$\mathbf{H}_{t+1}^{r(t+1)}$ and $\mathbf{S}_{t+1}^{rj(t+1)}$ are the values of human wealth and social security for a working retiree who retired at time t+1 but was still working at time t. The factor $\hat{N}_{t+1}^w$ augments the discount rate of the capitalized value of a worker's social security because with finite lives, the share of total social security entitlements going to those currently alive declines over time as the working-age population grows. By similar argument, $\hat{N}_{t+1}^w$ enters into the discount factor of human wealth.[11]

3.2.4 Distribution of wealth and aggregate consumption

Given our assumptions on preferences and population dynamics, there is no need to keep track of how assets and consumption are distributed within the groups of retirees and workers. However, since marginal propensities to consume differ as between the two groups, we must keep track of the distribution of assets *between* the two groups. Consequently, we need a state equation for distribution of wealth.

Let $\lambda_{t+1}^r \equiv \frac{A_{t+1}^r}{A_{t+1}}$ be the share of financial assets held by retirees and let $1-\lambda_{t+1}^r \equiv \frac{A_{t+1}^w}{A_{t+1}}$ be the share of financial assets held by workers. It can be shown that retirees' share of financial wealth evolves according to

$$\lambda_{t+1}^r = \left(1-\frac{\varepsilon_t \pi_t}{\nu}\right)\frac{R_t \lambda_t^r A_t}{A_{t+1}} + \frac{(1-\tau_t)\xi W_t N_t^r + \mathbf{T}_t^r - \frac{\varepsilon_t \pi_t}{\nu}(\mathbf{S}_t^r + \mathbf{H}_t^r)}{A_{t+1}/\omega_t} + \frac{(1-\omega_t)}{\omega_t} \tag{27}$$

[11] Note that in the limiting case of logarithmic preferences ($\sigma \to 1$) marginal propensity to consume is constant and equal to $1-\beta$.

Aggregate private consumption can then be obtained simply by summing up (15) and (22), using $\lambda_{t+1}^{f} \equiv \frac{A_{t+1}^{r}}{A_{t+1}}$ and that all assets are eventually held by domestic consumers

$$P_t^c C_t^H = \pi_t\left(\left[\left(1-\lambda_t^r\right)R_t A_t + \mathbf{H}_t^w + \mathbf{S}_t^w\right] + \varepsilon_t\left[\lambda_t^r R_t A_t + \mathbf{H}_t^r + \mathbf{S}\right.\right. \tag{28}$$

3.2.5 Assets

There are several types of financial assets available for consumers: domestic government bonds A_t^S, foreign bonds A_t^W, and stocks issued by domestic firms A_t^F. In addition, it is assumed that all the assets accumulated by the pension fund A_t^p are hold by domestic consumers.

Domestic one-period bonds pay a nominal return r_t, while the gross return on stocks is determined according to the profits of the firms in the model. Foreign bonds pay a return r_t^F, which is exogenously given. The arbitrage condition equates ex ante returns of domestic and foreign bonds, to give rise to uncovered interest rate parity (UIP) condition. The share price is the nominal price (ex-dividend) of a unit of equity in period t. The factor defining the gross return on stocks is the firms' Π_t^D. This gross return is defined as

$$1 + r_t^D = [A_{t+1}^F + (1 - \mathrm{t}_t^K)\Pi_t^D] / A_t^F \tag{29}$$

where t_t^K denotes the corporate tax rate. Optimal consumption plans can be combined with the arbitrage equation for holding different assets. This yields two equations that relate the after-tax interest rates to each other

$$r_t^D = r_t^S(1-\tau_t^S) + \mathrm{P}_t \tag{30}$$

$$1 + r_t^S = \left(1 + r_t^F\right)\frac{S_{t+1}}{S_t} \tag{31}$$

S_t denotes the nominal exchange rate, r_t^S denotes domestic short-term nominal interest rate and r_t^F denotes corresponding foreign short term interest rate. t_t^S is tax rate at source. The latter is a standard UIP condition. In addition to this, we assume an exogenously determined risk-premium P_t vs. domestic bonds for stocks issued by the domestic firms.

3.2.6 Labour markets

The model features nominal wage rigidity in the form of quadratic adjustment costs. A worker faces quadratic adjustment if when it has been allowed to re-set her wage. For those not able to optimize in period t, the wage is adjusted using the steady state growth rate of wages. This steady state growth rate of wages, denoted by $\overline{dw}$, equals steady state productivity growth plus inflation. The behavior of aggregate nominal wages is then characterized by the following two wage rate equations

$$W_t^* = \frac{\frac{(1-v)}{v} P_t^c C_t^w / (1-\tau_t)}{[N_t^w - L_t^w]} \tag{32}$$

$$W_t = \frac{(1-q)\beta\overline{dw}}{(1+\beta(1-q)^2\overline{dw}^2)} E_t W_{t+1} + \frac{(1-q)\overline{dw}}{(1+\beta(1-q)^2\overline{dw}^2)} W_{t\cdot} + \frac{q(1-(1-q)\beta\overline{dw}^2)}{(1+\beta(1-q)^2\overline{dw}^2)} W_t^* \tag{33}$$

where $P_t^c C_t^w$ is consumption of workers, N_t^w is worker population, L_t^w denotes the number of workers demanded, $q \in (0,1)$ is the exogenous probability that determines how often a randomly chosen worker is allowed to re-set her wage. The equation for optimal wage W_t^* is derived directly from the aggregate version of worker's labour supply decision.

Given that workers' and retirees' labour efficiency differ, we define aggregate effective labour supply index L_t as

$$L_t = L_t^w + \xi L_t^r \tag{34}$$

Here $\xi \in (0,1)$ denotes the relative efficiency of a unit of retirees' labour. Labour demand for workers L_t^w is derived from (34) by assuming that retirees are always on their labour supply curve at prevailing wage (W), and that the domestic intermediate goods producer is always on its labour demand curve.

3.2.7 Public sector

The general government (public sector) is divided into two sectors, labeled state (central government) and pension funds. The state collects taxes on labour income at the rate τ_t^{WS} from capital gains at τ_t^K and from consumption at τ_t^C. The state consumes C_t^S and pays transfers to workers and to retirees. In the budget constraint these total transfers are denoted T_t^S. In addition, the state issues one-period government bonds amounting to A_t^S and paying a nominal return of r_t. In each period, the following budget constraint holds

$$
\begin{aligned}
&-(A_t^S - A_{t-1}^S) \text{ (net lending)} \\
&= \mathrm{t}_t^{WS}(W_t L_t^w + \xi W_t L_t^r) \text{ (income tax revenues)} \\
&+\mathrm{t}_t^K \Pi_t \text{ (corporate income tax revenues)} \\
&+\mathrm{t}_t^C P_t^C C_t^F \text{ (indirect taxes)} \\
&+\mathrm{t}_t^{FS} W_t L_t \text{ (firms' social security contributions)} \\
&-P_t^C C_t^S \text{ (government consumption)} \\
&-\mathbf{T}_t^S \text{ (total net transfers)} \\
&-r_t A_{t-1}^S \text{ (interest payments)}
\end{aligned} \tag{35}
$$

3.2.8 Fiscal policy rule

Typically, models like this are closed by either a tax rule or by a lump sum transfer rule. We use a rather general form of tax rule that stabilizes the evolution of government debt via labour income tax. Formally, the tax rule takes a partial adjustment form[12]

$$
\tau_t^{ws} = \tau_{t-1}^{ws} - \theta_1(\tau_{t-1}^{ws} - \overline{\tau}^{ws}) + \theta_2(A_t^S - \overline{A}^S)/Y_t \tag{36}
$$

The tax rule has two attractors $\bar{\tau}$ and $\bar{A}^S/Y_t$ towards which the tax, and consequently the debt to output ratio are stabilized. Benchmark values for the parameters θ_1 and θ_2 have been calibrated to 0.3 and 0.1 respectively. $\overline{\tau}$ and $\overline{A}^S/Y$ can be set such that the public debt to output ratio reach wanted steady state values.

3.2.9 Statutory pension fund

There are several motivations for considering the pension fund(s) separately from the central government. First, when the pension scheme is defined benefit and partly funded, we should consider the funded part of the pension system as contractual saving, as opposed to discretionary saving, while the PAYG part should be considered a direct transfer from young generation (workers) to old generation (pensioners).[13] In Finland, where approximately 25% of the pensions are funded both features are quantitatively important.

Second, pension contributions are considered at least partly as taxes. Analogously with the previous section, this means that the way in which the increasing fiscal burden of aging is financed along the demographic transition

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[12] See e.g. Railavo (2004) for discussion of alternative fiscal policy rules and their stability properties

[13] In Finland, approximately 25% of the pensions are funded.

path is of crucial importance for the economy's labour market responses to ageing. The tradeoff is clearly between proportions of demographic transition financed by changing the pension fund asset position and by changing the contribution rates.[14]

Accordingly, we assume that the economy's pension fund is administrated separately from the central government. The fund collects pension contributions from the private sector and distributes pensions to retirees totaling $\mathtt{T}_t^{PR}$. Pension funds accumulate financial assets A_t^P. In each period, therefore, the following flow budget constraint holds for the pension fund

$$
\begin{aligned}
&-(A_t^P - A_{t-1}^P) \text{ (net lending)} \\
&= \mathrm{t}_t^P W_t L_t \text{ (social security contributions of employer and empl}\\
&-\mathtt{T}_t^{PR} \text{ (total transfers paid to retirees)} \\
&-r_t A_{t-1}^P \text{ (interest payments)}
\end{aligned}
\qquad (37)
$$

where $\mathrm{t}_t^P = \mathrm{t}_t^{FP} + \mathrm{t}_t^{WP}$ is overall pension contribution rate, consisting of employer and employee contributions. Finally T_t^{PR} denotes pensions and other transfers from pension funds to retirees.

3.2.10 Contribution rule

Inter-generational distribution of the fiscal burden of ageing is not actively managed by institutional control built into current pension schemes in general. According to Fenge and Werding (2003) `it merely just happens'. Consequently, inter-generational distribution is hardly an issue in devising the contribution rule for a model like ours. In a defined benefit pension system, such as in Finland, the contribution rate is adjusted to maintain the pension fund's fiscal balance. One way to write the pension fund's contribution rule, is to assume that the contribution rule stabilizes the net lending-to-total wage ratio at some predetermined long-run level.[15] Consequently, we write a simple `net lending' rule that stabilizes the net lending-to-total-wages ratio at a pre-specified target level. Formally

---

[14] A third important consideration is that pension funds hold the savings for the households that are completely illiquid. Households are thus not able to borrow, or are limited to a small amount, against their savings accumulated in the pension funds. This means that households do not see pensions accumulated in pension funds as perfect substitutes for more liquid forms of saving, such as bonds and equity. This is supported by empirical findings according to which growth in partially funded pension schemes does boost personal saving, but not one-to-one. The current version of the model, however, does not address this issue.

[15] Indeed, in Finland, pension funds' total net lending relative to aggregate wages has been rather stable during the last 25 years.

$$\tau_t^P = \tau_{t-1}^P + \theta_3 \left(\frac{(A_t^P - A_{t-1}^P)}{W_t L_t} + \overline{A}_{WL}^P \right) \tag{38}$$

Where $\overline{A}_{WL}^P$ is the target level for net lending-to-total-wages and θ_3 is an adjustment parameter. This form is flexible enough for policy option experiments. For instance setting $\overline{A}^P$ at zero and θ_3 high represents a pure PAYG system. In our benchmark simulations, we set $\theta = 0.15$ and $\overline{A}^P = 0.07$.

3.2.11 Pension expenditures

Allowing idiosyncratic historical dependence in social security and pension payments would make the model more realistic, but it would sacrifice analytical tractability. We thus link the model's pension expenditures/transfers to the demographic structure and aggregate wages, by writing

$$T_t^R = \mu_t N_t^r W_t \tag{39}$$

where $\mu_t = \overline{e}_t / \overline{W}$ is the average pension rate evaluated at the initial steady state level of aggregate wages $\overline{W}$. Since the wage rate W_t is endogenous, we obtain projections for pension expenditures once we set a deterministic path to average pension rate μ_t. Total pension expenditures T_t^R are thus linked to average wages and number of pensioners in the model. Furthermore, making use of our demographic assumptions, we can express pension expenditures per capita in terms of the dependency ratio, wages and pension rate:

$$\frac{T_t^R}{N_t} = \mu_t \frac{N_t^r}{N_t} W_t = \mu_t \frac{\varphi_t}{1+\varphi_t} W_t \tag{40}$$

3.2.12 Production sector

The supply side is based on a single intermediate good that can be used in the production of final goods. Producers of this intermediate goods combine capital and labour using a constant-elasticity-of- substitution (CES) production function and operate in monopolistic product markets. Prices of final goods are sticky in the form of Calvo-pricing. Domestic producers of intermediate products purchase their capital inputs (capital services) in a competitive capital market (from companies providing capital services) in which capital is freely sold and transferable for use by other companies. Building up new capital generates cost - adjustment costs - in the form of lost capital stock.

Domestic intermediate goods are combined with imported intermediate goods to produce final goods of three kinds: consumption goods, capital goods and exported goods. The production function – or, rather, aggregator – is CES. The production differs across final goods in terms of elasticity of substitution. All three types of final producers operate in competitive product markets, in which they take the market price for their products as given in their own decision-making.

Finally, nominal import prices are assumed to be sticky in a manner corresponding to domestic intermediate goods prices. It is also assumed that, in the short run exchange rate pass-through to import prices is incomplete. This is due to the fact that a fixed portion of import companies price their products in the local currency.

3.2.12.1 Domestic intermediate goods producer

The domestic composite intermediate good, Y_t, is produced according to a constant elasticity of substitution (CES) production function, which combines a continuum of individual goods $Y_t(j)$ $j \in [0,1]$ (Dixit and Stiglitz, 1977)

$$Y_t = \left[\int_0^1 Y_t(j)^{-\rho^z} dj \right]^{\frac{1}{-\rho^z}}.$$

The parameter $\rho^z \in [-1, \infty)$ determines the elasticity of substitution $1/(1+\rho^z)$. Cost minimization implies the following conditional demand function for the individual good i

$$Y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\frac{1}{1+\rho^z}} Y_t$$

The price index for the composite domestic intermediate good is

$$P_t = \left[\int_0^1 P_t(j)^{\frac{\rho^z}{1+\rho^z}} dj \right]^{\frac{1+\rho^z}{\rho^z}}$$

Domestic intermediate goods, $Y_t(j)$, are produced by producers operating in monopolistic market. The production technology and the factor augmenting technical trends are exogenously given. The production function is of the CES type and takes a specific constant-returns-to-scale form[16]

$$Y_t(j) = \left[\delta \left(\Lambda_t^K K_t \right)^{-\rho} + (1-\delta) \left(\Lambda_t^L L_t^F \right)^{-\rho} \right]^{-1/\rho}$$

[16] Jalava, Pohjola, Ripatti and Vilmunen (2006) provide evidence that this may be a reasonable approximation for the Finnish post-WWII data.

The factors of production include homogeneous capital services, K_t, and labour input L_t^F. Λ_t^K and Λ_t^L denote time-varying[17] capital and labour-augmenting technical progress respectively. The elasticity of technical substitution is given by $1/(1+\rho)$, where ρ is the substitution parameter and δ the share parameter in the production function. The technical change is labour-augmenting, Λ_t^L, in the balanced growth path.

Cost minimization implies the following real marginal costs

$$\frac{MC_t(j)}{P_t(j)} = \left[\delta^{\frac{1}{1+\rho}} \left(\frac{R_t}{\Lambda_t^K P_t(j)} \right)^{\frac{\rho}{1+\rho}} + (1-\delta)^{\frac{1}{1+\rho}} \left(\frac{W_t^F}{\Lambda_t^L P_t(j)} \right)^{\frac{\rho}{1+\rho}} \right]^{\frac{1+\rho}{\rho}}$$

where R_t denotes the nominal rental price of capital services and $W_t^F = (1+\mathrm{t}_t^F)W_t$ represents nominal labour costs including employers' pension and social security contributions. In the steady-state prices $P(j)$ are determined by markup, $\Upsilon(=-\frac{1}{\rho^z})$ over marginal costs

$$P(j) = \Upsilon MC(j) \tag{41}$$

The first order conditions (in logs) with respect to capital services and labour are given by

$$r_t - p_t = \log\delta - \log(\Upsilon) - \rho\log\Lambda_t^K + (1+\rho)(y_t - k_t) \tag{42}$$

$$w_t^F - p_t = \log(1-\delta) - \log(\Upsilon) - \rho\log\Lambda_t^L + (1+\rho)(y_t - l_t) \tag{43}$$

Due to the monopolistic competition in the market for output, the slope of the demand curve, $\upsilon \equiv \log(\Upsilon)$, enters into both first order conditions.

The dynamics of the price level $P_t(j)$ of producer i arise from the assumption that a firm changes its price level when it receives a random `price-change signal'. A constant probability of receiving a price change signal is given by $1-\zeta$($\zeta \in [0,1]$). Since there is a continuum of intermediate producers, $1-\zeta$ also represents the share of producers that have received such a signal and thus are able to change their prices. The average time between price changes is given by $1/(1-\zeta)$. Solving the first order condition and linearizing in a standard way yields the following aggregate pricing equation for the intermediate goods producer

---

[17] See Ripatti and Vilmunen (2001) for further discussion of their properties and estimates using aggregate Finnish data.

$$\Delta p_t = \beta E_t \Delta p_{t+1} + \frac{(1-\zeta)(1-\zeta\beta)}{\zeta}\left[\upsilon + mc_t - p_t\right]. \tag{44}$$

Inflation is determined by expected inflation and log markup υ over the real marginal costs $mc_t - p_t$.

3.2.12.2 Capital rental firms

Capital is a homogeneous factor of production that is owned by a firm that rents capital to producers of domestic intermediate goods. It operates under perfect competition. Physical capital accumulation generates real adjustment costs in the form of lost capital stock. Capital accumulation is given by

$$K_t^p = I_t - \mathbf{S}\left(K_t^p, K_{t-1}^p, K_{t-2}^p\right) + K_{t-1}^p\left(1-\delta_K\right) \tag{45}$$

where $\mathbf{S}(\cdot)$ denotes the adjustment costs of physical capital stock and δ_K is the capital depreciation factor. The capital rental firm maximizes its expected discounted profits

$$\max_{\{I_t\}} E_t \sum_{s=0}^{\infty} M_{t,t+s} \Pi_{t+s}^K \tag{46}$$

subject to the capital accumulation equation (45) and the definition of capital services,[18] $K_t = K_{t-1}^p$. Its momentary profits are given by

$$\begin{aligned} \Pi_t^K &= R_t K_t - P_t^I I_t \\ &= R_t K_{t-1}^p - P_t^I \left(K_t^p + \mathbf{S}_t(K_t^p, K_{t-1}^p, K_{t-2}^p) - K_{t-1}^p(1-\delta_t\right. \end{aligned} \tag{47}$$

The price index of investment goods, P_t^I, is the price index of the domestic investment good retailer and R_t denotes rental rate for capital. Future profits are discounted using the nominal stochastic discount factor (pricing kernel) $M_{t,t+s} = \beta^s U'(C_{t+s}) P_t^C / [U'(C_t) P_{t+s}^C]$. The first order condition with respect to capital stock K_t^p is given by

[18] For simplicity we assume that capital services are determined by the lagged value of physical capital stock. In a more general case by Ripatti and Vilmunen (2004) capital services depend also on the endogenous utilization rate. This extension alters the results only in business cycle frequencies and is thus beyond the interest of this study.

$$
\begin{aligned}
&-P_t^I E_t\left[1+\mathsf{s}_t'(K_t^p,K_{t-1}^p,K_{t-2}^p)\right] \\
&+E_t M_{t,t+1}\left\{R_{t+1}-P_{t+1}^I\left[\mathsf{s}_{t+1}'(K_{t+1}^p,K_t^p,K_{t-1}^p)-\left(1-\delta^K\right)\right]\right\} \\
&-E_t M_{t,t+2}\left[P_{t+2}^I\mathsf{s}_{t+2}'(K_{t+2}^p,K_{t+1}^p,K_t^p)\right]=0.
\end{aligned} \tag{48}
$$

Due to the end-of-period timing of physical capital stock, the accumulated physical capital is in use in the following period. Hence, the expected following period's rental rate R_{t+1} governs the current period investment decision. The adjustment cost function is quadratic in changes of the physical capital stock

$$
\mathsf{s}_t(.)=\frac{\gamma_1}{2}\frac{\left(\Delta K_t^p-\gamma_2\Delta K_{t-1}^p\right)^2}{K_{t-1}^p}. \tag{49}
$$

The usual `investment equation' can be obtained by substituting the parametric version of adjustment costs into the first order condition.

3.2.12.3 Production of final goods

The economy is inhabited by two retailers that produce final goods, one producing consumer goods and the other capital goods. They combine domestic intermediate inputs, produced by intermediate goods producers, and imported goods and services, and operate under perfect competition. The demand for retailers' output is given by consumption and investment of the private and general government sectors. The output of the consumption-goods retailer divides into the private consumption and public purchases of market goods, $C_t^T \equiv C_t^H + C_t^{SF}$. The capital-goods retailer faces similar demand comprising private sector and public sector investment, $I_t^T \equiv I_t + I_t^S$. The production technology is CES for both retailers[19]

$$
Q_t^j=\left[\delta^j\left(Y_t^j\right)^{-\rho^j}+(1-\delta^j)\left(M_t^j\right)^{-\rho^j}\right]^{-1/\rho^j},\quad j=I,C^T
$$

δ^j is the respective share parameter and ρ^j the respective substitution parameter ($\sigma^j=1/(1+\rho^j)$). M^j denotes imports and Y^j the domestic intermediate good. Cost minimization generates following price indices,

$$
P_t^j=(1-\mathrm{t}_t^c)^{-1}\left[(\delta^j)^{\frac{1}{1+\rho^j}}\left(P_t\right)^{\frac{\rho^j}{1+\rho^j}}+(1-\delta^j)^{\frac{1}{1+\rho^j}}\left(P_t^{Mj}\right)^{\frac{\rho^j}{1+\rho^j}}\right]^{\frac{\rho^j+1}{\rho^j}}
$$

---

[19] We abstract from the time-varying factor augmenting technical progress, which reflects changes in preferences for domestic and imported intermediate goods.

and the conditional factor demands,

$$Y_t^j = \left(\delta^j\right)^{1+\rho j}\left(\frac{P_t}{(1-\mathrm{t}_t^c)P_t^j}\right)^{\frac{-1}{1+\rho^j}} Q_t^j$$

$$M_t^j = (1-\delta^j)^{1+\rho^j}\left(\frac{P_t^{Mj}}{(1-\mathrm{t}_t^c)P_t^C}\right)^{\frac{-1}{1+\rho^j}} Q_t^j .$$

The consumption-goods retailer pays the indirect taxes, t_t^C. Hence the tax base for indirect taxes consists of private consumption and government purchases. No indirect taxes are levied on investment goods.

The elasticity of substitution between imported consumption goods and domestic intermediate products has been estimated by Ripatti and Vilmunen (2004). Using cointegration techniques they find that $\hat{\rho}^C = -0.7731$ (standard error 0.049) implying that the elasticity of substitution is 4.4. δ^C is calibrated at 0.87. The estimation of elasticity of substitution between imported investment goods and domestic intermediate goods suggests a value of 2.2, which is given by the estimate of $\hat{\rho}^I = -0.538$ (standard error 0.183). This means that the factors are gross-substitutes. The calibrated value of the share parameter δ^I is 0.67.

The exporter is a firm that combines domestic intermediate inputs Y_t^X and imported raw materials M_t^R to produce export good X_t in competitive markets. Technology and preferences are identical to those of the retailers. Ripatti and Vilmunen (2004) assume that the imported-raw-materials-augmenting technical change may contain a deterministic linear time trend. This trend captures the structural change in input usage of exports. The estimate of the elasticity of substitution is 0.45, implying that $\rho^X = 1.217$ (standard error 0.378). Not surprisingly, the point estimate suggests that the imported raw materials and the domestic intermediate input are gross-complements in the production of exported goods and services. The calibrated value of the share parameter δ^X is 0.51.

3.2.12.4 Importing firms

Imported goods and services are used by the retailers and the exporter. They combine imported and domestically produced intermediate goods to produce final consumption, capital and exported goods. The consumer goods and services (including 5% of imported energy) are used by the consumption-goods retailer, capital goods and services are used by the capital-goods retailer, and the exporter uses energy and intermediate goods in producing exported goods. Both retailers operate under perfect competition in the output markets. A model for import prices of imports by main use, i.e. for the retailer sector, is derived by via the approach of Betts and Devereux (1996) and (2000) applied to the Finnish aggregate import data by Freystätter (2003). A portion of importers price their products in local (Finnish) currency and the other importers in producers' own currencies. Their pricing contains identical frictions in the form of Calvo (1983b), ie they can change their price only if they receive a random signal allowing them to optimize a new price. Their marginal costs are identical. The aggregation of pricing behaviour over these two types of importers yields an import-price Euler equation where import prices depend on expected future import price inflation, current and expected future changes in foreign exchange rates, and on importers' real marginal costs. This brings incomplete exchange rate pass-through into the model.[20]

3.2.13 Market equilibrium

All markets are in equilibrium at all point of times. The capital goods market is in equilibrium when the supply of capital services by the capital-rental firm equals the demand for capital services by intermediate goods producers. Similarly the labour markets are in equilibrium when the demand for labour equals its supply, $L_t^s = L_t^D$. In the intermediate goods sector, the demand for intermediate goods by retailers and exporters equals total supply

$$Y_t^C + Y_t^I + Y_t^X = Y_t. \tag{50}$$

Markets for final goods clear when

$$\begin{aligned} C_t^S + C_t^H &= C_t^T \\ I_t^G + I_t &= I_t^T \\ \left(\frac{P_t^X}{S_t P_t^W}\right)^{-\rho^W} M_t^W &= X_t, \end{aligned} \tag{51}$$

where P_t^W is the aggregated export price of competing economies and M_t^W is aggregate imports of export markets. When market clearing conditions hold, the workers' and pensioners' budget constraints and , the general government budget constraint (12) and (20) the pension fund's budget constraint (budget, pension fund) imply the following equation for the accumulation of foreign assets

$$S_t A_t^W = (1 + r_t^F) S_t A_{t-1}^W + \underbrace{P_t^X X_t - P_t^{MR} M_t^R - P_t^{MC} M_t^C - P_t^{MI} M_t^I}_{\text{trade balance}} \tag{52}$$

---

[20] As incomplete exchange rate pass-through is not essential for the ageing simulations provided in this paper, we abstract from explicit derivation. Derivation is provided in Ripatti and Viertola (2004).

The current account balance is given by $S_t(A_t^W - A_{t-1}^W)$ and the factor income account by $r_t^F S_t A_t^W$.

3.3 Policy designs

3.3.1 An overview of the pension system and pension reform in Finland

The model developed above will be used to study population ageing and policy experiments in the small open economy of Finland. First, we set out the Finnish pension scheme and pension reform effective since 2005.

The pension scheme in Finland is defined benefit in the sense that pension benefits are not directly dependent on contributions of workers to employment pension schemes or/and the yields of pension funds. Instead, of total benefits being changed, it has been contribution rates that have been altered in response to possible shortfalls in the balance. When there has been a danger of a shortfall in the agreed funding rate, the level of contributions has been raised. The second general feature of the Finnish system is the negligible role of private and occupational pension schemes of private firms. Nearly all old age pensions are provided by employment pension institutions or national pension institutions closely controlled by the state.

The latest reform, effective from the start of 2005, changed the pension system in line with more actuarial principles. With the introduction of flexible retirement age, 63 to 68, the level of pensions becomes linked more explicitly than before with exit age and thus with contributions made by the insured. Furthermore, starting from 2009, changes in life expectancy will have an effect on pension levels. In addition, pension indexation has been changed so that all pensions will be indexed using weights of 0.8 for living costs and 0.2 for wages, whereas before a `midway index' was applied up to age 65. This will contribute to a comparative erosion in pension values, and thus to a decline in the pension replacement ratio μ, compared to wage level. Contributions are collected from employers and employees. Currently, 16.8% is collected on average from employers and 4.6% from employees. It has been agreed that further changes in contribution rates will be shared equally (50-50) between employers and employees. Due to the benefit-based nature of the Finnish employment pension system, long-term aggregate pension expenditure can be approximated simply from demographic factors and parameters determining average pension benefits. The most important factors are naturally demographic trends and the average age at which people start to draw pensions, which together determine the total number of pensioners. The average level of pensions is affected by wage levels and the pension index, and thus by consumption prices and productivity developments. In addition, changes in life expectancy will have an effect on level of benefits so that the replacement rate became dependent on exit age.

3.3.2 Model's calibration – initial steady state

For the purpose of simulating the model, the quantity variables are de-trended by the labour-augmenting technical factor Λ_L, population N_t and the numeraire price level P_t. As for labour market variables, the nominal wage is scaled by the labour augmenting technical change Λ_L and consumption deflator P_t^C. Labour supply indices are scaled by population N_t. Finally, all the other price variables are de-trended by the numeraire price level P_t.

In order to set up the model for demographic simulations and policy experiments, we assume that the economy is initially in the steady state. The economy is growing on the balanced growth path and the demographic structure is stable. The model's key parameters are then calibrated to reflect the main features of the Finnish economy. The key parameters are calibrated so that the key `great ratios', factor shares, participation rates, demographic structure as well as fiscal variables reflect the situation in the Finnish economy on average during the last 10 years. The parameters of the production functions were estimated using co-integration methods (Johansen, 1995), and the parameters related to capital stock adjustment costs, depreciation function and import prices are estimated using GMM.[21] Tables (calibemand) – (calibupply) characterize the calibration of some of the key parameters and resulting values of the key endogenous variables. We next comment on the calibration of key parameters.

In order to fit the participation rates observed we set the relative efficiency of retirees at roughly 30%. Elasticity of periodic utility with respect to consumption was at 0.8 and inter-temporal elasticity of substitution at 0.4. The public-finance literature tends to use values well below unity for the inter-temporal elasticity of substitution, while the RBC literature prefers large value of σ. Typically, smaller value of σ makes the economy react more strongly to fiscal stimulus (Table 1).

Reflecting a calibrated value of periodic utility of consumption, the value for the Frisch elasticity of labour supply for workers is in line with international microeconomic studies, which report the values of 0.15 - 0.32.[22] Kuismanen (2005a, 2005b) has also estimated compensated labour supply elasticities using Finnish Labour Force survey data. Depending on the data sample and methods used, his estimates range from 0.08 to 0.30. The distribution of wealth between working-age and elderly persons seems reasonable in light of the demographic structure: 17% of the model economy's total financial wealth is owned by retirees. Ω is an additional factor that multiplies the worker's discount factor.

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[21] For detailed description of estimation strategies, see Ripatti and Vilmunen (2004).

[22] Bayomi, Laxton and Pesenti (2004) use the value 0.33 in the standard calibration of GEM for the euro area.

This additional discount factor is clearly higher than those obtained in Gertler (1999). The difference is largely explained by the distorting nature of taxes. Similarly, retirees marginal propensity to consume is `only' 60% higher than that of the workers.[23]

Table 1 Calibration of key demand side parameters

Variable	**Explanation**	**Value**
β	subjective discount factor, parameter	0.99
v	elasticity of periodic utility with respect to consumption	0.80
σ	Inter-temporal elasticity of substitution, parameter	0.45
ξ	Labour efficiency of retirees, parameter	0.30
ε	Relative marginal propensity to consume, variable	1.59
π	Worker's marginal propensity to consume, variable	0.019
λ^F	Distribution of financial asset wealth, variable	0.17
Ω	Additional discounting factor	1.10
$\bar{v}^w$	Frisch elasticity of labour supply (workers), variable	0.26
$\bar{v}^r$	Frisch elasticity of labour supply (pensioners), variable	0.23

Regarding parameters affecting most strongly to pension system and demographic structure, we assume that individuals work on average 43 years and stay in retirement for about 15 years. Annual growth rate of working age

[23] We assume that average expected time between price changes is 5 quarters, while wage changes occur on average only every 8 quarters. In comparison to the literature, wage changes occur seldom, but the values reflect the Finnish centralized wage setting system and the fact that centralized wage contracts are usually set for 1 - 2 years time in Finland. Similarly, the Calvo parameter for prices is on the high side.

population is set at 0.18% per annum (Table 2). The steady state retiree worker ratio then amounts to 33%, in accord with recent data The pension rate is calibrated at 0.55, which, given endogenous average wage and demographic structure means, that pension expenditures amount to 20%% of total wages, also roughly in accord with recent data. Finally, the pension contribution rate to employees is 3.9 per cent, while the employees' contribution rate amounts to 15.4%, so that overall pension contribution rate is 19.3%.

Table 2 Calibration of key parameters of the pension system

Variable	Explanation	Value
$\frac{1}{1-\gamma}$	Expect ed time of retirement, in years, parameter	14.8
$\frac{1}{1-\omega}$	Expected time of working, in years, parameter	43.1
$\hat{N}^{w}$	Annual growth rate of working age%, parameter	0.18
φ	Old age dependency ratio, variable	0.33
τ^{WP}	Pension contribution rate of the workers%, implicit	3.9
τ^{FP}	Pension contribution rate of the firms%, parameter	15.4
$\mathbf{T}^{R}$	Pensions,% of wage sum, variable	20.5
μ	Pension rate	0.55

Regarding public sector (excluding pension fund) it is assumed that the steady state debt to output ratio is 60%, while total public consumption amounts to 20.8% of output (Table 3). Total social security transfers to workers are 6.4% of output. Finally labour income tax rate is calculated endogenously so as to satisfy the state's budget constraint, while the rest of the tax parameters have been set exogenously reflecting the current tax system in Finland.

Table 3 Calibration of key parameters of the state

Variable	Explanation	Value
κ	Fiscal rule adjustment, parameter	0.1
a^S	Debt (% of output), variable	60.0
τ^{WS}	Income tax rate% of workers, implicit	30.2
τ^K	Corporate tax rate%, parameter	19.2
τ^C	Indirect tax rate%, parameter	21.0
τ^{FS}	Firm's social security contribution rate, parameter	4.0
c^S	Public consumption (% of output), variable	20.8
$\mathbf{T}^{SW}$	Total transfers to workers (% of output), variable	6.4

Regarding the supply side of the economy, we assume that the real interest rate is about 2.4% per annum (Table 4). The economy grows on the balanced growth path at the rate of 2.3% per annum, reflecting the labour-saving technical change and steady state growth rate of the population. Given the small size of Finland in the euro area, the feedback from Finnish economy to euro area level is very modest. Thus a reasonable approximation is that the euro area policy rate is exogenous and that the nominal exchange rate is fixed. The foreign nominal interest rate determines the domestic nominal interest rate up to the UIP condition. On the balanced growth path, inflation is set at 2.0% in accord with the inflation target of the ECB.

Price markup and the share price-to-equity ratio are roughly in accord with empirical evidence,[24] while capital share parameter and elasticity of substitution between capital and labour have been estimated from historical data by Ripatti and Vilmunen (2001). Capital depreciation rate is set to 8% per annum.

[24] Kilponen and Santavirta (2005) estimate from microdata that the percentage share of operating profits in the value of gross output in Finnish manufacturing firms was roughly 8% during the last decade.

Finally, Table 5 summarizes key `great ratios', factor shares, net foreign asset position and employment rates at initial equilibrium. Comparison with recent data shows that the model fits the data reasonable well. The model's current calibration, however, involves some difficulties in capturing the relatively low investment and private consumption shares observed in the data.

Table 4 Calibration of key parameters for the supply side

Variable	Explanation	Value
$\overline{R}^F / \hat{P}^c$	Real interest rate, p.a., variable	2.4
$\hat{Y}$	Output growth rate, p.a., variable	2.3
$\hat{\Lambda}_L$	Labour saving technical change p.a., parameter	2.08
δ^K	Capital depreciation rate, parameter	0.08
Υ	Price markup, parameter	1.08
$\overline{A}^F / \overline{\Pi}$	Price to equity ratio, variable	15.0
δ	capital share parameter	0.1
ρ	El. of substitution between capital and labour	0.72

Table 5 Great ratios, factor shares and participation rates

Variable	Explanation	The data 1995-2005	Steady State
c^H	Private consumption share, %	51.3	54.0
i	Private investment rate, %	15.8	18.6
x	Export share, %	39.8	34.0
m	Import share, %	31.1	34.0
ls	Labour share, %	49.5	51.5
k/l	Capital intensity	4.8	4.3
a^w	Net foreign assets, %	-42.5	-23.3
l	Employment rate, %	58.6	55.4
l^w	Workers	56.6	53.8
l^r	Retirees	2.1	5.2
Shares calculated in nominal terms except for capital intensity			

3.3.3 Policy experiments

In order to facilitate analysis of fairly complex general equilibrium effects associated with ageing and different assumptions that can be made about the pension parameters, we designed some alternative demographic scenarios and policy experiments. The long-run implications of ageing population are treated as shocks to the initial state of unchanged demographic age structure and steady pace of population growth. We performed five different simulations altogether, as reported in table Shocks.

Table 6 Demographics shocks relative to initial steady state

	Experiment				
Change	I	II	III	IV	V
Expected period of retirement, years	5.0	5.0	5.0	5.0	5.0
Growth rate of workers, percent annually		-0.5	-0.5	-0.5	-0.5
Expected working time, years			2.5	2.5	2.5
Pension replacement rate, %-points				-10	μ*
*endogenous					

The shock simulating population ageing incorporated both the higher life expectancy projected in the population forecast and the slowdown in the growth of working-age population. Higher life expectancy was simulated by increasing the expected period of retirement by 5 years (table Shocks, columns I-II) and then supplementing the shock with a longer expected working time of 2.5 years, while taking into account the slowdown of the growth of working age population (Table 6, column III).

Experiment II is a pure demographic shock that captures the main demographic trends. According to the latest population prognoses, the fastest growth in the old age dependency ratio will take place in the 2020s and 2030s, when the baby boom generation, born after the Second World War, retires. After that, the ratio will grow at a slower pace. The overall dependency ratio is projected to level off by the 2030s. Immigration is forecast to remain insignificant, at only 5000 persons a year net. Finally, according to Statistics Finland estimates, the life expectancy for men will rise from the current 75.1 years to 82.1 years by 2040. For women the corresponding figures are 81.8 and 86.8 years.

Features inherent in the pension scheme, i.e. deferred retirement in response to accelerated accrual and a lower replacement rate, were built into the demographic effects by lowering the pension replacement rate by 10 percentage points (column IV). The analysis was completed with an equilibrium calculation where the replacement rate was endogenously defined while the rate of employee contribution was kept unchanged, at its initial steady state level (column V).

3.4 Long-run effects of ageing

3.4.1 Increasing life expectancy

Increase in life expectancy projected in the demographic forecast for Finland alone would have a pronounced effect on the economy's long-run equilibrium. Extension of the period of retirement by five years, as assumed in the calculation, would imply an increase in the old-age dependency ratio of 11 percentage points. This would lead to 6.3 percentage point increase in total pension expenditures relative to total wages. Tax burden on labour would raise by more than 3.7 percentage points and would be reflected in falling employment rates. The total contribution rate would rise by 6.7 percentage points. (Table 7, column I). Given age cohorts of the same size and a stable fertility rate, higher life expectancy alone would impose a considerable burden on the economy. The falling employment rate of workers is attributable to a higher tax burden on labour, so that the after-tax wage rate declines slightly. These factors are reflected in rising real wages in the long-run. The consumption response, measured as a share of output, reflects households' different marginal propensities to consume. Retirees own a larger share of the economy's financial wealth and are more willing than workers to consume it. Mirror effect of this is that capital share is higher in the aged economy.

3.4.2 Declining fertility rate

Considering that age cohorts entering the labour market are smaller than those withdrawing, the old-age dependency ratio would increase by almost 16 percentage points (Table fiscalongerm, column II). Tax rate and employment responses would also be pronounced, in that the pension contribution rate would increase by 8.8 percentage points and the income tax rate by 3.4 percentage points. The employment rate would fall by almost 6 percentage points reflecting a marked increase in real wages. The private consumption share would increase by 6.2 percentage points relative to the initial state of constant population growth. The major increase in tax rates is related not only to pension expenditures but also to the strong response of workers' employment rates. This reduces tax bases, even if retirees supply more labour. Retirees positive labour supply response is attributable to a longer retirement period.

Table 7 Long-run effects of ageing

		Final Steady State, Change				
Variable	Explanation	I	II	III	IV	V
φ	Old-age dependency ratio**	10.9	15.5	13.0	13.0	13.9
t^P	Contribution rate**	6.7	8.8	7.0	1.3	a) 0.0
t^{WS}	Labour income tax rate**	2.3	5.0	3.4	0	-0.7
$\frac{T^R}{WL}$	Pension expenditure/wage sum**	5.3	8.0	6.7	2.0	1.0
w	c) Real wage*	5.4	5.3	6.0	9.5	10.3
$(1-t)w$	c) After-tax real wage*	-0.38	-5.6	-1.6	9.5	11.5
c^H	Private consumption share*	5.1	6.2	6.4	6.8	13.6
λ	Wealth distribution**	3.4	6.1	5.2	5.5	5.6
l	Employment rate**	-3.7	-5.7	-4.7	-3.3	-3.0
l^w	Workers	-4.3	-6.2	-5.2	-4.3	-4.2
l^r	Retirees	2.1	1.8	1.6	3.5	3.7
k	Capital share*	21.0	23.5	22.4	21.1	21.0
a^w	Net foreign assets**	4.8	21.1	27.1	51.2	56.7
μ	Pension replacement rate**	0	0	0	-10.0	b) -12.0
y	Output, efficiency units	-1.7	-5.5	-3.4	-0.5	0.12
* Percentage change relative to initial steady state						
** Change, percentage points relative to initial steady state						
a) Contribution rate kept fixed at initial steady state, b) endogenous, c) in effociency units						

3.4.3 Pension reform and a lower replacement rate

It has been estimated that the pension reform will extend labour force participation by an average of 2 - 3 years. This alone would clearly ease the burden of an ageing population (Table 7, column III). The need to increase the contribution would be reduced by 1.8 percentage points. Similarly, the need to raise the labour income tax rate would decrease almost as much, compared to the pure demographic shock. This would in turn be reflected in smaller employment losses in the long-run.

The decline in average replacement induced by the rules of pension indexation also has a considerable effect on sustainability of the pension scheme. This effect was measured by the assumption that the ratio of average pension to average wage would decline by 10 percentage points, i.e. clearly less than that suggested by the calculation discussed above. This would considerably reduce the need to raise the contribution rate in response to population ageing in the long-run. The labour income tax rate could be kept at the current level, and contribution rates would need to be raised only by 1.3 percentage points. (Table 7, column IV). Pension expenditure would raise 4.7 percentage points less than the figure returned by the previous simulation (column III).

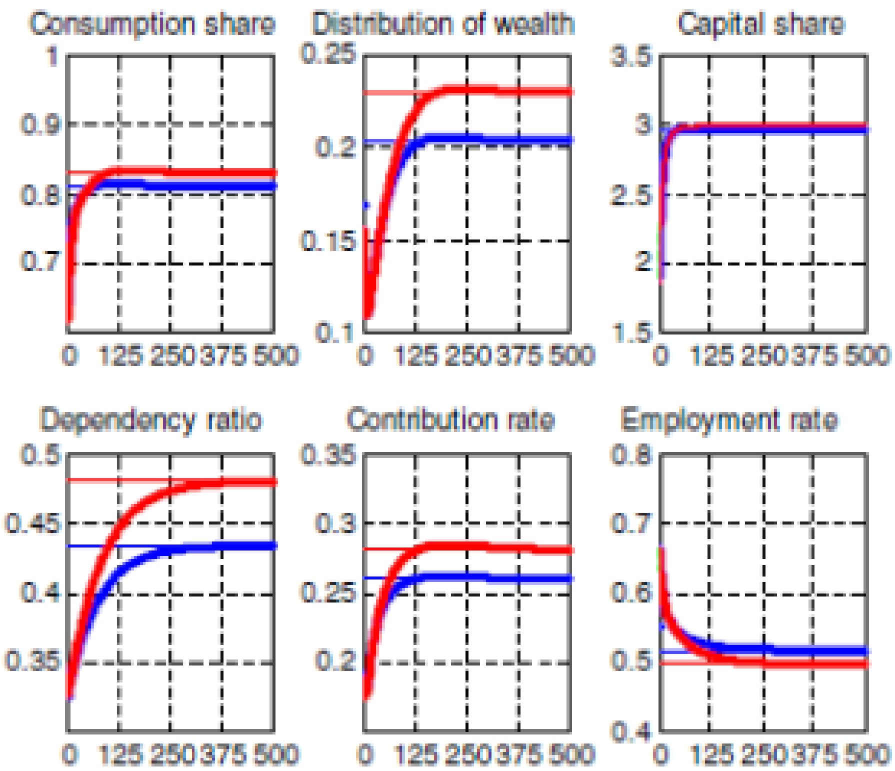
According to the results of the equilibrium calculation based on given rate of contribution, we find that pensions would, in the long-run, have to decline from their current levels by 12 percentage points relative to average wages (Table 7, column V). This would ensure that the ratio of pension expenditure would increase only by 1% percentage point relative to total wages in response to population ageing. However, real wages would still increase by 10%, while the employment rate would fall by 3 percentage points. Once more, retirees' incentives to work would be improved, primarily because of the wealth effect compared to the previous experiment. Finally output would remain virtually intact in this case.

3.5 Dynamic effects

Dynamic optimization and perfect foresight assumption implies that the transition paths of the macroeconomic variables reflect the way in which optimizing agents prepare for a new demographic situation. These adjustment paths are further complicated by our assumption that demographic structure is changing over time. The adjustment paths can typically involve over- or undershooting of forward looking variables, even though the transitional path of a demographic shock is a smooth slowly evolving process. One such variable is consumption, which typically initially jumps and then begins gradually to adjust to the new long-run steady state. This is reflected in over- or undershooting of wages and employment, given that leisure and consumption are non-separable in the periodic utility.

Figure1 shows how the model economy responds to a pure anticipated shock to retirement age (I) and to the shock where the fertility rate drops as described in experiment II.[25]

Figure 1 *Pure demographic shocks and transition.(Blue line corresponds to experiment I and red line to experiment II. Periods are quarters.)*



After a temporary drop in distribution of wealth (in favour of workers), retirees eventually hold a larger share of the economy's financial wealth. The worker's tax burden on labour follows a similar pattern. Aggregate consumption reacts in advance of anticipated demographic change and starts stabilizing well before the demographic change is over. Beyond the response of aggregate consumption, there are opposite responses of retirees and workers. While the workers increase saving for retirement by reducing their consumption, and also because of a higher tax burden, retirees respond positively. Retirees are also now more numerous as shown by the gradual rise in the dependency ratio. A lower fertility rate, besides

[25] All the simulations were done using *DYNARE,* version *3.051.*

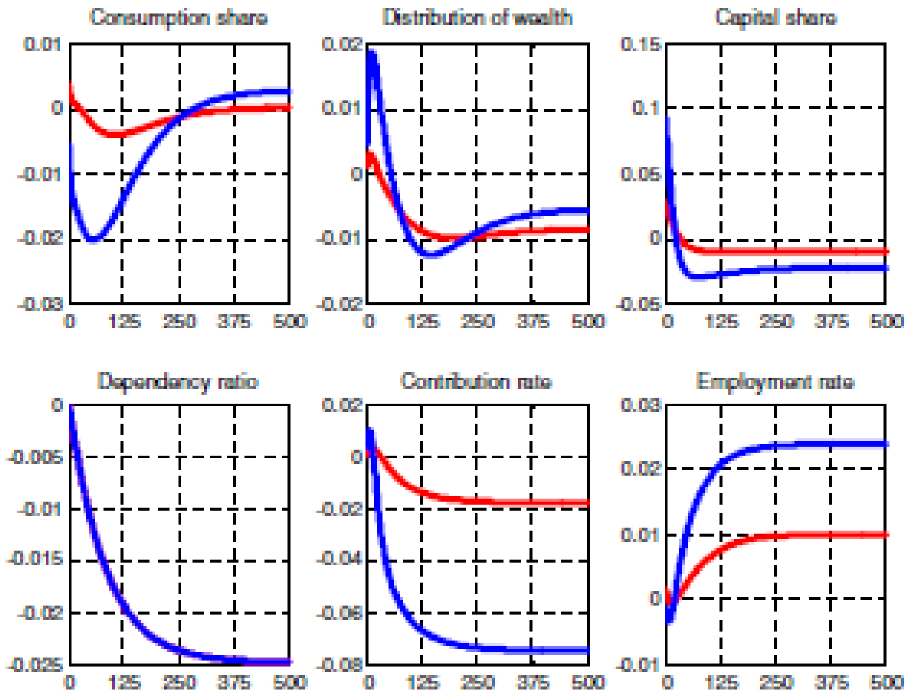
increasing life expectancy, gradually increases the dependency ratio and leads to a further increase in the pension contribution rate. This effect is also associated with a slightly higher consumption share and lower employment rate.[26]

Figure 2 illustrates how an extension of working life and a lower replacement rate alleviate the effects of a pure demographic shock. Consumption share is practically intact (red (lighter gray) line), while the need to increase contribution rates gradually ease along with a less pronounced increase in the dependency ratio. Capital share increases initially with the extension of working life but eventually returns to a very close to the same level as with a pure demographic shock. Longer working time means that there is a roughly one percentage point improvement in employment rate compared to a pure demographic shock. Extending the simulation by taking into account also a lower pension replacement rate shows that the consumption share may now fall in the short and medium term. A drop in the replacement rate reduces pensioners' permanent income, with a subsequent temporary fall in consumption levels. As the need to raise the contribution rate gradually eases, employment improves rather quickly, while consumption bounces back only after a several decades. Mirroring this, there is also a temporary fall in capital share and a permanent fall in distribution of wealth held by the retirees.[27]

[26] Higher long-run capital and consumption shares are compatible with the Blanchard-Yaari asset market equilibrium condition. In essence, the condition produces a positive relationship between consumption and capital stock, as required by the current account balance in an open economy.

[27] These results are naturally subject to uncertainty regarding calibrated and estimated parameter values of the model, as well as assumptions on the external environment of the economy and demographic projections. In particular inter-temporal substitution (σ) and elasticity of periodic utility with respect to consumption (ν) guide the dynamic and long run response of consumption, real wages and employment, which in turn matter how the tax burden on labour evolves in response to population ageing. Subsequent sensitivity analysis shows that a higher value of inter-temporal substitution mitigates the effects of pure demographic shock on taxes, while the opposite is true for lower values of σ. Parameter ν affects primarily on the long-run response of the economy to population ageing as well as the initial steady state. Sensitivity analysis suggests that higher values of ν lead to somewhat smaller response of the contribution rate which in turn is associated with a slightly smaller negative response of employment.

Figure 2. *Extensions of working life and lower replacement rate ease fiscal burden of ageing.(Red line corresponds fo experiment III, blue line to experiment IV; baseline is a pure demographic shock; periods are quarters.*



3.5.1 Demographic uncertainty

Population scenarios and ageing reflect projected changes in fertility rates and longevity. These population scenarios are however subject to much uncertainty. OECD (2005) has reported that in the case of Finland, overall uncertainty surrounding longevity and fertility rate projections suggests that the dependency ratio will fluctuate ±10 percentage points around the official scenario.[28] Rather similar results were obtained in the project `Uncertain Population of Europe' (UPE) funded by the EU Commission. In this project, stochastic population forecasts were generated by simulating 3,000 alternative paths of future development for age-specific mortality, fertility and net migration for different European countries. These different scenarios were then combined into

[28] Assessing the robustness of demographic projections in OECD countries, Frederic Gonand, Economics Department Working Papers, No. 464, OECD)

population scenarios using the classical cohort-component book-keeping equations. Based on the resulting age-specific cohort tables from different simulations, table demographic uncertainty, Table 1 summarizes the statics related to the old-age dependency ratio relevant to the model. This helps us anchor the degree of uncertainty related to the old-age dependency ratio in Finland and thus quantify the degree of uncertainty related to demographic trends. The table suggests that risks of making large errors in population forecasts increase after 2020, making the confidence limits expand quite fast (see also Alho (1998)).

Table 8 *Summary statistics from stochastic population simulations (based on own calculations from http://www.stat../tup/euupe/)*

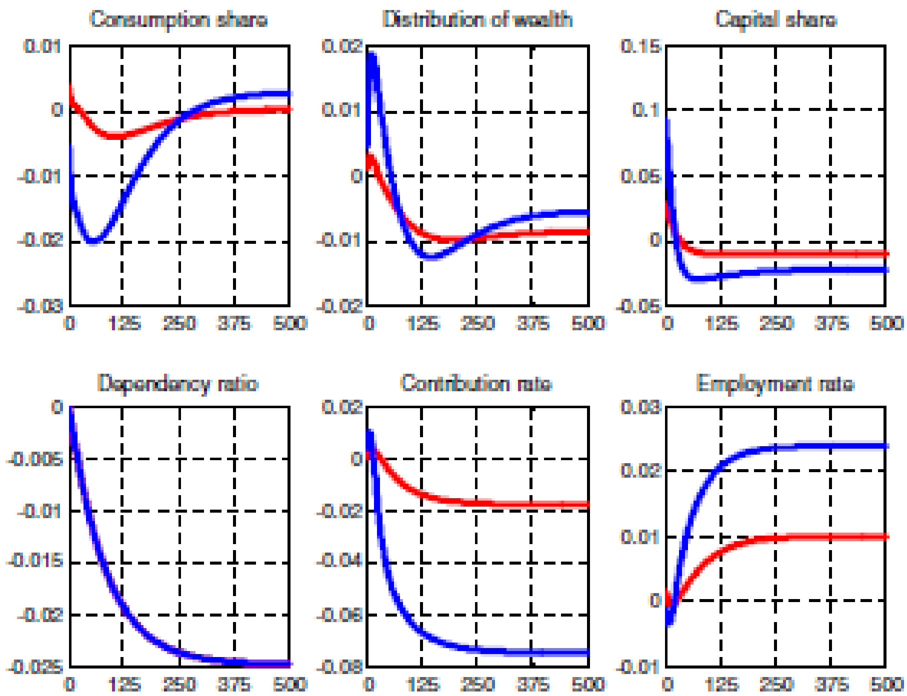
Year	Min	Mean	Max	S.E.
2010	0.40	0.42	0.43	0.005
2020	0.48	0.54	0.61	0.019
2030	0.49	0.64	0.74	0.043
2040	0.41	0.65	0.94	0.071
2050	0.36	0.67	1.08	0.099

In order to quantify how the demographic uncertainty feeds into the model's outcomes, we take experiment III as a baseline (see table Shocks), but allow for stochastic variation in retirement probability ($1-\omega_t$), survival probability (γ_t) and worker's growth rate $\hat{N}_t^w$. Allowing for stochastic variation in these variables generates stochastic variation for the model's endogenous variables along the transition path.[29] We calibrate the uncertainty in retirement probability and survival probability such that the 90% confidence intervals for working time and retirement are respectively ±2 and ±4 years at the final steady state of the model. Furthermore, we assume that the population growth rate has a 90% confidence interval of 0.5% in annual terms. This generates empirically plausible variation in dependency ratio, amounting to a 4% standard error. Figure 3 shows the 90% confidence intervals generated by these assumptions on the relevant demographic

[29] DYNARE's functions *forecast* and *stoch_simul* allow mixing of deterministic and stochastic shocks.We are indebted to Michel Juillard for developing these functions.

variables, while table demographic uncertainty, Table 9 summarizes the results for selected endogenous variables at the final steady state.

Figure 3 *Mean outcome and 90% confidence intervals generated by the stochastic variation in retirement probability, survival probability and population growth rate.*



It is evident that there much uncertainty about economic outcomes of the model, once uncertainty as to demographic structure is accounted for. A standard error of 4% for the dependency ratio translates to roughly a 3 percentage point standard error in the labour income tax and contribution rates. Variation in the employment rate is roughly 2 percentage points.

Stochastic simulations allow us also to quantify the relative importance of different demographic shocks to economic outcomes. This can be done by looking at (asymptotic) variance decomposition as generated by the stochastic simulations of the model. Although the results of variance decomposition depend on the assumed relative standard errors of the shocks, columns 5 - 7 in table demographic uncertainty, Table 2 clearly suggest that lengthening the working time has rather minor effect on alleviating the fiscal burden of ageing: Only about 3% of the stochastic variation in the contribution rate is explained by the variation in working period. Stochastic variation in the time spent in retirement is clearly more important.

Table 9 *Asymptotic moments from stochastic model simulations for selected model's variables*

Variable	Explanation	Mean	Standard Error	Variance Decomposition		
				ω	N_t^W	γ
e	Dependency ratio	0.46	0.04	3.7	3.8	92.5
t^P	Contribution rate	0.28	0.03	3.7	1.6	94.7
t^{WS}	Labour income tax rate	0.42	0.03	3.7	2.1	94.2
$\frac{T^R}{WL}$	Pension exp/wage sum	0.28	0.02	3.6	3.9	92.4
y	Output, efficiency units	0.18	0.01	3.6	1.9	92.4
L/N	Employment rate	0.49	0.02	3.5	2.8	93.7
$4(1-\omega)^{-1}$	Working time, years	45.5	1.2			
$4(1-\gamma)^{-1}$	Retirement, years	19.4	2.5			
$\hat{N}_t^W$	Growth rate of workers	-0.33	0.3			
a) All the moments are evaluated at final steady state						

3.6 Conclusions

As industrialized countries prepare for population ageing, pension reforms have been designed with the aim on increasing incentives to work longer and/or cutting pension benefits. One prominent example from Europe is Finland, where the latest pension reform introduced a flexible retirement age of between 63 and 68.

Using a tractable dynamic general equilibrium model calibrated to Finland, we show that even if the effective retirement age were to increase as expected, the burden from pension payments alone would cause the income tax rate to rise to a level above that witnessed in the worst years of recession in the mid-1990s. A stochastic simulation exercise suggests also that lengthening the working time has a rather minor impact on alleviating the fiscal burden of ageing: only a minor part of the stochastic variation in the contribution rate is explained by the variation in working period.

On the contrary, if the replacement rate falls, as seems likely under the current pension regime, there would be a much smaller increase in taxation in response to growing expenditure on pensions. The average decline in the level of pensions relative to wage developments in turn raises several concerns. In Finland, where supplementary pension funds are of minor importance by international standards there is a risk that the falling purchasing power of pensions relative to wage developments will exert pressure on other social security schemes. The employee pension scheme, which appears to be financially sustainable, may thus in practice generate costs to local and central government in the form of higher expenditure on income support and other benefits.

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4. Government funds and demographic transition - Alleviating ageing costs in a small open economy[30]

Helvi Kinnunen

4.1 Introduction

Population ageing will have profound effects on PAYG public pension schemes all over the western world. Financing of promised pension benefits requires large tax hikes causing distortions for the labour market and income distribution across generations. For the European countries, where the old age dependency ratio is expected to roughly double during the next four decades, the ageing stress is particularly severe. Consequently, in order to ensure sustainability of public pension schemes, a series of pension reforms are considered. In addition, provisions for prefunding of public pension schemes are taken in most European countries [31]. By funding part of the future pension outlays governments try to smooth the tax burden over time.

This paper focuses on the role of government funds during demographic transition. More specifically, we analyse to what extent public pension funds can be used as an instrument to lower the adjustment costs during the demographic transition. Adjustment is considered under condition that the long term sustainability of the public pension schemes will be maintained. We consider the role of the public pension funds in Finland, which contains features crucial from the point of this study. The Finnish pension system is partly funding PAYG with defined benefit features. Most importantly, substantial public pension funds are already collected but nevertheless the situation of public finances is unsustainable requiring increases in pension contribution rates in the long term. Other key feature from the point of view of this study is that pension funding is collective. This means that pension funding rate do not affect the expected future wealth of households. In addition, while pension benefits are earnings-related at invidual level[32], on the aggregate level changes in the general contribution rates

[30] This is based on the Bank of Finland Discussion Paper Helvi Kinnunen: Government funds and demographic transition - alleviating ageing costs in a small open economy Nro 21/2008, Bank of Finland.

[31] See discussions on European pension reforms for example in Holzmann, MacKellar and Rutkowski (2003)

[32] Pension contributions accrue to future pension benefits according to certain accrual rates without upper limits in pension benefits.

do not affect pension benefit. Accordingly, changes in contributions will have the same kinds of efficiency costs as those attributed to wage taxation. Finally, Finland is hit by an exceptionally large demographic shock, and, contrary to most other European countries, in Finland demographic change is already in progress. In addition, unlike in most European countries, the coverage of the mandatory public pension scheme is extensive. In practice, private voluntary pension insurance is quite negligible.

Role of the pension funds in alleviating economic reactions on demographic change arises from the distortiory effects of the labour taxation. If taxation could be lowered by cutting down prefunding, we could reduce the distortions on behaviour arising particularly from the substitution of leisure for work in response to taxation on labour. By reducing deadweight loss, the lower taxation could also change allocation of resources. In a small open economy labour market reactions lower wage levels and, accordingly, pension costs, which for its part increase the share of pension payments the return on pension funds covers. These channels are incorporated into the DSGE model we use in this study. It includes two age groups and facilitates analysing distortionary effects of fiscal and pension policy responses to ageing. The defined benefit PAYG pension system with wage-dependent pension benefits and collective prefunding is incorporated into the model. Households' wealth includes social security wealth in the form of discounted pension entitlements, independent of funding and contribution rates, and ageing shocks represent current population prognoses. The model contains separate fiscal policy rules and accounts for the state and public pension institution. Moreover the supply side is explicitly modelled.

Kilponen, Kinnunen, Ripatti (2006) considered demographic shock and the consequences of some policy experiments using the same DSGE model. It was calibrated to represent the Finnish pension scheme, demographic developments as well as macroeconomic relations. That paper highlighted the central role of responses of workers and retirees to tax changes. This paper extends this analysis by modifying fiscal policy rules in order to give an active role to the pension funds in smoothing ageing effects on the economy. Focus is also more on the near future when the demographic shock is largest. Other literature relating this paper is Guest (2008) of tax smoothing between generations with explicit distortionary tax effects. Also Oksanen (2003 and 2008) examined intergenerational tax smoothing but without explicit tax reactions. Close to our point of view is also funding adjustment in a small open economy examined in Bovenberg and Knaap (2008). Pension funding and fiscal policy rules are studied in Jafarov and Leigh (2007). Generally, in the literature of pension funding, the focus has been in analysing consequences of movement from a publicly provided

PAYG based pension scheme towards private investment based funding [33]. Also the effects of pension funding on financial markets, capital movements and the macroeconomy in multiregion models have been investigated [34]. Otherwise ageing-related stress on the economy has been typically analysed by evaluating pension reforms under clear tax-benefit links, where efficiency losses in terms of employment have been typically absent [35]. In addition, since the analysis usually have concentrated on the closed economy case, a funding-induced increase in national saving tends increase real capital formation and productivity, thereby improving long term growth prospects. In our case, under a public prefunding framework with weak or absent tax-benefit linkages, the advantages of funding are not clear-cut, particularly since in a small open economy framework real interest rate reactions do not support economic growth. Besides the costs of tax distortions, in defined benefit framework, prefunding does not increase the wealth of households.

Simulation experiments of this study indicate that substantial gains can be achieved by funding adjustment during demographic transition. Cutting down on pension prefunding at a time when the pace of ageing is at its peak reduces the necessary tax hikes and stimulates labour supply growth at the moment when the labour market is tightest. Under lower funding, ageing leads to less growth of labour costs, better employment and faster production growth. Given the collective nature of pension funding, cutting back on funding did not redistribute welfare between retirees and workers. By lowering wage pressures and consequently pension benefits, a smaller prefunding is needed to produce the same welfare level than in the benchmark with unchanged pension funding rate. In the steady state, cut down of funds by 20 percentage points of the wage bill did not lower the welfare level.

The rest of the paper is organized as follows. Section 3.2 introduces the model, including a description of the pension system. Sections 3.3 discuss the results from policy experiment. Section 3.4 concludes.

4.2 The Model

Our analysis is based on Gertler's (1999) overlapping generations model. It merges the perpetual youth model of Yaari (1965) and Blanchard (1985) with an important aspect of life-cycle behaviour. The model is an extension of Gertler's

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[33] See for example Feldstein (2005), Bergstrom and Hartman (2007), Demange (2007) and MCMorrow and Roeger (2004) as well as OECD (2007) for discussions of costs of pension prefunding.

[34] Attanasio et al. (2006) and Börsch-Supan et al. (2003) as well as Saarenheimo (2004)

[35] See for example Jaag, Keuschnigg, and Keuschnigg (2007) and Nickel, Rother and Theophilopoulou (2008).

model in the sense that it allows for distortionary taxation and time varying demographics. Households are forward looking with stochastic transition from work to retirement and from retirement to death, which captures the life cycle behaviour of households. The defined benefit pension system is part of households' social security wealth and, accordingly, future pension entitlements are considered equal to other public transfers.

OLG features of the model facilitate investigating intergenerational aspects. Supply side (production structure) is based on CES production technology with factor augmentation in the underlying technological progress and nominal and real rigidities. The model is closed by fiscal rules. Budgetary solvency of public finances is achieved by setting an explicit target for public pension funds and a debt target for other government finances. In a small open economy, any imbalance between domestic savings and investment is reflected in the net foreign asset position.

Given our focus on the policy of public funding, the key relationships are the setting of fiscal policy rules and the way taxation affects the labour market, households' wealth and intergenerational wealth distribution [36]. The benchmark for the simulations is an economy where ageing-related demographic change is already incorporated in the model outcome.

4.2.1 Households

A household smooths consumption over the lifecycle and lives for two distinct periods: in the first period as a worker and in the second as a retiree. Transitions from work to retirement and from retirement to death are captured by parameters measuring the length of the working period and life-expectancy.

4.2.1.1 Demographics and preferences

Demographic parameters vary in time and are set to produce a realistic demographic structure. Dependency ratio, $\varphi_t = \frac{N_t^r}{N_t^w}$, is expressed as

$$\varphi_t \equiv \frac{N_t^r}{N_t^w} = \frac{1-\omega_t}{\hat{N}_t^w} + \gamma_t \frac{\varphi_{t-1}}{\hat{N}_t^w} \tag{1}$$

where the number of working population $\hat{N}_{t+1}^w$ grows at an exogenous growth rate $1+n_{t+1}^w$ and γ_t is the probability that an individual remains a worker in the

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[36] The model and the impact of population ageing in a DSGE model is reported in detail in Kilponen, Kinnunen and Ripatti (2007).

next period, while the probability of retiring is $1-\omega_t$. Once an individual has retired, she faces a periodic probability of death of $(1-\gamma_t)$.

In the steady state, the demographic change has ended, so that

$$\varphi = \frac{1-\omega}{\hat{N}-\gamma} \tag{2}$$

$$\hat{N} = \hat{N}^w = \hat{N}^r \tag{3}$$

Households smooth consumption over the lifecycle and maximize a welfare function formulated separately for worker and retiree. Workers' preferences reflect the period at work and the expected period at retirement while retirees take into account, beyond retirement period, also the 'interim' period when they participate in the labour market upon retirement. This categorising is needed to enable us to capture the tax effects on labour supply of retirees. Preferences are summarized as

$$V_t^z = \left\{ \left[\left(C_t^z \right)^v (1-l_t^z)^{1-v} \right]^{\rho_c} + \beta^z [E_t (V_{t+1} \mid z)]^{\rho_c} \right\}^{\frac{1}{\rho_c}}$$

where

$$E_t(V_{t+1} \mid w) = \omega_t V_{t+1}^w + (1-\omega_t) V_{t+1}^r, \; \beta^w = \beta \tag{4}$$

$$E_t(V_{t+1} \mid r) = V_{t+1}^r, \; \beta_t^r = \beta\gamma_t. \tag{5}$$

$z = w, r$ indicates whether the individual is a worker or retiree. The finite (constant) intertemporal elasticity of substitution $\sigma = 1/(1-\rho_c)$ indicates the willingness to smooth consumption over time. Parameter υ is the elasticity of periodic utility with respect to consumption. The retirees' effective discount factor β^r takes into account the periodic probability of death.

A Retiree

The maximisation problem for a retiree born at time j, retiring at time k and surviving at least until $t+1$ is:

$$\max_{C_t^{rjk}, l_t^{rjk}} V_t^{rjk} = \left\{ \left[\left(C_t^{rjk} \right)^v (1-l_t^{rjk})^{1-v} \right]^{\rho_c} + \beta\gamma_t [E_t (V_{t+1}^{rjk})]^{\rho_c} \right\}^{\frac{1}{\rho_c}} \tag{6}$$

s.t.

$$A_{t+1}^{rjk} = \frac{1}{\gamma_t} R_t A_t^{rjk} + W_t (1 - \mathrm{t}_t) \xi l_t^{rjk} + \mathbf{T}_t^{rjk} - P_t^c C_t^{rjk} \tag{7}$$

where R_t denotes after-tax gross rate of return on financial assets A_t^{rjk} and $\mathbf{T}_t^{rjk}$ denotes pension benefits. Retirees who participate in the workforce are assumed to have lost part of their efficiency compared to workers. Relative efficiency is denoted by $\xi < 1$. Efficiency slow-down captures, besides real labour productivity, also other factors that lowers retirees' labour input as measured by work days, such as part time work. Parameter β is the subjective discount factor, P_t^c is a price index for consumption and t_t is the total labour income tax rate including pension contribution rate, t_t^{WP}.

Retirees' human capital is $\mathbf{H}_t^r$ and social security wealth $\mathbf{S}_t^r$. Wealth is valued on a net basis, after wage taxes and taxes levied on pension income as well as pension contributions. Maximizing with respect to consumption and aggregating over retirees results in the following aggregate consumption equation for retirees

$$P_t^c C_t^r = \varepsilon_t \pi_t [R_t A_t^r + \mathbf{H}_t^r + \mathbf{S}_t^r]. \tag{8}$$

where $\varepsilon_t \pi_t$ is retirees' marginal propensity to consume out of wealth. H_t^r and S_t^r represent discounted after-tax labour income and pensions. They evolve as

$$\mathbf{H}_t^r = (1 - \mathrm{t}_t) W_t \xi L_t^r + \frac{\mathbf{H}_{t+1}^r}{\hat{N}_{t+1}^r R_{t+1} / \gamma_{t+1}} \tag{9}$$

$$\mathbf{S}_t^r = \mathbf{T}_t^r + \frac{\mathbf{S}_{t+1}^r}{\hat{N}_{t+1}^r R_{t+1} / \gamma_{t+1}}. \tag{10}$$

The growth rate of retirees $\hat{N}_{t+1}^r$ is entered into the discount factor because total social security payments (pensions) are distributed equally among retirees. Also the discount factor for human wealth is augmented by the growth rate of retirees. Retiree's marginal propensity to consume out of wealth $\varepsilon_t \pi_t$ evolves according to the following non-linear difference equation:

$$\varepsilon_t \pi_t = 1 - \left(\frac{W_t / P_t^c}{W_{t+1} / P_{t+1}^c} \frac{(1 - \mathrm{t}_t)}{(1 - \mathrm{t}_{t+1})} \right)^{\frac{(1-\nu)\rho_c}{1-\rho_c}} \beta^{\frac{1}{1-\rho_c}} \left(\frac{R_{t+1}}{\hat{P}_{t+1}^c} \frac{\gamma_t}{\gamma_{t+1}} \right)^{\frac{\rho_c}{1-\rho_c}} \frac{\varepsilon_t \pi_t \gamma_{t+1}}{\varepsilon_{t+1} \pi_{t+1}} \tag{11}$$

where $\hat{P}^c_{t+1} \equiv P^c_{t+1} / P^c_t$. A retiree's marginal propensity to consume varies with the real interest rate, $R_{t+1} / \hat{P}^c_{t+1}$, as well as with expected changes in real net wage income. In addition, the survival probability γ, influences a retiree's effective discount rate, thereby introducing further dynamics into the marginal propensity to consume equation.

A Worker

The maximation problem for a worker born at time s is

$$\max_{C_t^{ws}, l_t^{ws}} V_t^{ws} = \left\{ \left[\left(C_t^{ws} \right)^{v} (1 - l_t^{ws})^{1-v} \right]^{\rho_c} + \beta [E_t (V_{t+1}^{ws})]^{\rho_c} \right\}^{\frac{1}{\rho_c}} \tag{12}$$

s.t.

$$A_{t+1}^{ws} = R_t A_t^{ws} + (1 - \mathrm{t}_t) W_t l_t^{ws} + \mathbf{T}_t^{ws} - P_t^c C_t^{ws} \tag{13}$$

where $\mathbf{T}_t^{ws}$ denotes financial transfers to workers and t_t is the total labour income tax rate. After intertemporal maximization, the worker's consumption plan aggregates to

$$P_t^c C_t^w = \pi_t [R_t A_t^w + \mathbf{H}_t^w + \mathbf{S}_t^w]. \tag{14}$$

where π_t is the worker's marginal propensity to consume and H_t^w and S_t^w denote human and social security wealth.

Marginal propensity to consume out of wealth follows a non-linear first order difference equation:

$$\pi_t = 1 - \left(\frac{(1 - \mathrm{t}_t) W_t / P_t^c}{W_{t+1} / P_{t+1}^c} \right)^{\frac{(1-v)\rho_c}{1-\rho_c}} \beta^{\frac{1}{1-\rho_c}} \left(\frac{\Omega_{t+1} R_{t+1}}{\hat{P}_{t+1}^c} \right)^{\frac{\rho_c}{1-\rho_c}} \frac{\pi_t}{\pi_{t+1}} \tag{15}$$

where Ω_{t+1} is the factor that weights the gross real return $R_{t+1} / \hat{P}^c_{t+1}$. This factor evolves according

to

$$\Omega_{t+1} = \left(\frac{1}{1 - \mathrm{t}_t} \right)^{1-v} [\omega_t + (1 - \omega_t) \varepsilon_{t+1}^{-\frac{1-\rho_c}{\rho_c}} \left(\frac{1}{\xi} \right)^{1-v}] \tag{16}$$

where $\varepsilon_{t+1} > 1$ is the ratio of a retiree's marginal propensity to consume to that of a worker.

$\mathbf{H}_t^w$ is the discounted sum of a worker's wage bill (in net terms) and $\mathbf{S}_t^w$ is the sum across workers alive at t of the capitalized value of social security (in net terms). Both of these measures take account of the corresponding discounted values at the time of retirement. Formally,

$$\mathbf{H}_t^w = \frac{\omega_t \left(\frac{1}{1-\mathrm{t}_{t+1}}\right)^{1-\upsilon} \mathbf{H}_{t+1}^w}{R_{t+1}\Omega_{t+1}\hat{N}_{t+1}^w} + (1-\mathrm{t}_t)W_t L_t^w + \frac{(1-\omega_t)(\varepsilon_{t+1})^{\frac{1-\rho_c}{\rho_c}} \left(\frac{1}{\xi(1-\mathrm{t}_{t+1})}\right)^{1-\upsilon} \varphi_{t+1}^{-1}\mathbf{H}_{t+1}^{r(t+1)}}{R_{t+1}\Omega_{t+1}\hat{N}_{t+1}^r} \tag{17}$$

$$\mathbf{S}_t^w = \mathbf{T}_t^w + \frac{\omega_t \left(\frac{1}{(1-\mathrm{t}_{t+1})}\right)^{1-\upsilon} \mathbf{S}_{t+1}^w}{R_{t+1}\Omega_{t+1}\hat{N}_{t+1}^w} + \frac{(1-\omega_t)(\varepsilon_{t+1})^{\frac{1-\rho}{\rho}} \left(\frac{1}{\xi(1-\mathrm{t}_{t+1})}\right)^{1-\upsilon} \varphi_{t+1}^{-1}\mathbf{S}_{t+1}^{r(t+1)}}{R_{t+1}\Omega_{t+1}\hat{N}_{t+1}^r} \tag{18}$$

$\mathbf{H}_{t+1}^{r(t+1)}$ and $\mathbf{S}_{t+1}^{rj(t+1)}$ are the values of human wealth and social security for a working retiree who retires at time $t+1$ but is still working at time t. The enlarged discount rate due to the presence of $\Omega_{t+1} > 1$ in the denominator means that workers value human wealth and social security less than does a retiree. This tends to reduce the worker's consumption and increase saving compared to a retiree.

The factor $\hat{N}_{t+1}^w$ augments the discount rate of the capitalized value of a worker's social security because the share of total social security entitlements going to those currently alive declines over time as the working-age population grows. By a similar argument, $\hat{N}_{t+1}^w$ enters into the discount factor of aggregate human wealth.

4.2.1.2 Labour and wages

Standard labour supply for a retiree born at time i, retiring at time k and surviving at least until $t+1$ and a worker born at time s evolve as

$$1 - l_t^{rjk} = \frac{1-v}{v} \frac{P_t^c C_t^{rjk}}{(1-\mathrm{t}_t)\xi W_t} \tag{19}$$

$$1-l_t^{ws} = \frac{1-v}{v}\frac{P_t^c C_t^{ws}}{(1-\mathrm{t}_t)W_t} \tag{20}$$

where t_t denotes taxes levied on labour income.

In the model, the worker faces a quadratic adjustment in re-setting the wage rate. A fraction of workers is assumed to adjust wages in each period. For those not able to optimize in the period, the wage is adjusted using the steady state growth rate of wages, denoted $d\overline{w}$, which equals the steady state productivity growth rate plus the inflation rate.

The behaviour of aggregate nominal wages is then characterized two wage rate equations:

$$W_t^* = \frac{\frac{(1-v)}{v} P_t^c C_t^w / (1-\mathrm{t}_t)}{[N_t^w - L_t^w]} \tag{21}$$

$$W_t = \frac{(1-q)\beta d\overline{w}}{(1+\beta(1-q)^2 d\overline{w}^2)} E_t W_{t+1} + \frac{(1-q)d\overline{w}}{(1+\beta(1-q)^2 d\overline{w}^2)} W_{t-1} + \frac{q(1-(1-q)\beta d\overline{w}^2)}{(1+\beta(1-q)^2 d\overline{w}^2)} W_t^* \tag{22}$$

where $P_t^c C_t^w$ is consumption of workers, N_t^w is worker population, L_t^w denotes the number of workers demanded, $q \in (0,1)$ is the exogenous probability that determines how often a randomly chosen worker is allowed to re-set her wage. The equation for the optimal wage rate, W_t^*, is derived directly from the aggregate version of worker's labour supply decision.

Workers' and retirees' aggregate labour supply is derived by multiplying individual labour supplies by population shares:

$$L_t^r = \frac{\varphi_t}{(1+\varphi_t)} - \frac{1-v}{v}\frac{P_t^c C_t^r}{(1-\mathrm{t}_t)W_t \xi} \tag{23}$$

$$L_t^W = \frac{1}{(1+\varphi_t)} - \frac{1-v}{v}\frac{P_t^c C_t^w}{(1-\mathrm{t}_t)W_t} \tag{24}$$

Aggregate labour supply is measured by the effective labour supply index, L_t, which takes into account differences in workers' and retirees' labour efficiency:

$$L_t = L_t^w + \xi L_t^r \tag{25}$$

Labour demand for workers, L_t^w, is derived by assuming that retirees are always on their labour supply curve at the prevailing wage (W), and domestic intermediate goods producers are on their labour demand curve.

4.2.1.3 Wealth distribution, financial assets and aggregate consumption

Since workers discount wealth at a higher rate than retirees, they tend to consume a smaller part of any wealth increase. This means that the distribution of wealth is an essential element in aggregate consumption.

Using previous equations for human and social security wealth, the share of financial wealth held by retirees $\lambda_{t+1}^r \equiv \frac{A_{t+1}^r}{A_{t+1}}$ evolves according to

$$\lambda_{t+1}^r = (1 - \frac{\varepsilon_t \pi_t}{\nu}) \frac{R_t \lambda_t^r A_t}{A_{t+1}} + \frac{(1-\tau_t)\xi W_t N_t^r + \mathbf{T}_t^r - \frac{\varepsilon_t \pi_t}{\nu}(\mathbf{S}_t^r + \mathbf{H}_t^r)}{A_{t+1}/\omega_t} + \frac{(1-\omega_t)}{\omega_t} \tag{26}$$

where $\mathbf{H}_t^r$ and $\mathbf{S}_t^r$ denote discounted after-tax values of labour income and pensions as defined above, and $\varepsilon_t \pi_t$ is retirees marginal propensity to consume out of wealth.

Assuming that all assets are eventually held by domestic consumers, aggregate private consumption is

$$P_t^c C_t^H = \pi_t \left([(1-\lambda_t^r) R_t A_t + \mathbf{H}_t^w + \mathbf{S}_t^w] + \varepsilon_t [\lambda_t^r R_t A_t + \mathbf{H}_t^r + \mathbf{S}_t^r] \right) \tag{27}$$

Individuals receive transfers from both the central government and pension funds. However, in order to maintain analytical tractability, pensions are related to the prevailing aggregate wage level but not to individual characteristics.

Financial assets available to consumers consist of three items: domestic government bonds, A_t^S, foreign bonds, A_t^W, and stocks issued by domestic firms, A_t^F. Pension funds invest in the same assets. Their investment is denoted by $-A_t^p$. In simulations, asset returns on domestic and foreign bonds are assumed to equalize ($r_t^S = r_t^F$). The share price r_t^D is the nominal price (ex-dividend) of a unit of equity in period t. The factor defining the gross return on stocks is firms' profits, Π_t^D. This gross return is defined as

$$1+r_t^D = [A_{t+1}^F + (1-\mathrm{t}_t^K)\Pi_t^D]/A_t^F \tag{28}$$

where t_t^K denotes the corporate tax rate.

4.2.1.4 Welfare

Workers welfare can be written using (Vrjk) and (Vws) and the corresponding optimality condition for consumption and labour as

$$V_t^w = \pi_t^{-\frac{1}{\rho}}\left(C_t^w / P_t^c\right)\left(\frac{1-v}{v}\frac{P_t^c}{(1-t)W_t}\right)^{1-v} \tag{29}$$

Retirees' welfare evolves analogously to that of the workers with differences only in propensity to consume and in labour efficiency rate:

$$V_t^r = (\varepsilon_t\pi_t)^{-\frac{1}{\rho}}\left(C_t^R / P_t^c\right)\left(\frac{1-v}{v}\frac{P_t^c}{(1-t)W_t\xi}\right)^{1-v} \tag{30}$$

Given that agents maximise welfare over their life-cycles, welfare measures represent discounted future value for an average worker or a retiree at each moment. Consequently, the welfare effects of a policy or economic shock depends on its direct impact on wealth and on its impact on discount rates. Moreover, welfare is affected by tax-distortions from the labour market.

4.2.2 Social security

4.2.2.1 Pension expenditures and fiscal balances

The model's pension expenditures are linked to the demographic structure and aggregate wages such that $\mathrm{T}_t^R = \mu_t N_t^r W_t$, where μ_t $\left(= \bar{e}_t / \overline{W}\right)$ is the average pension rate evaluated at the initial steady state level of aggregate wages $\overline{W}$. Total pension expenditures, T_t^R, are thus linked to average wages and the number of pensioners. Making use of our demographic assumptions, we can express pension expenditures per capita in terms of the dependency ratio, wages and pension rate:

$$\frac{\mathrm{T}_t^R}{N_t} = \mu_t\frac{N_t^r}{N_t}W_t = \mu_t\frac{\varphi_t}{1+\varphi_t}W_t \tag{31}$$

Pension expenditure is the component that brings ageing structure to social security wealth. Other transfers for households are assumed to evolve in line with production growth. In simulating demographic shocks, we have pension benefits depend on wage developments over the longer time, thereby imitating the actuarial structure of the pension system.

General government is divided into two sectors: state government (central and local governments) and pension funds. Separation of sectors allows us to investigate pension funding apart from other fiscal policy questions. This is well-grounded from the intergenerational viewpoint since tax treatment differs for retirees and workers. On the public spending side, in turn, pension outlays are in principle equal to other public transfers not linked to tax payments. In that sense pension funding is equivalent to government debt[37].

The fiscal balance of the state consists of three taxes: labour income is taxed at the rate t_t^{WS} , capital gains tax levied at the rate t_t^{K} and consumption taxed at the indirect tax rate t_t^{C} . State expenditure items are consumption, C_t^S, transfers to firms and households, T_t^S, and interest payments on government debt with nominal rate of , r_t. The state issues government bonds amounting to A_t^S in a net basis. In each period, the following budget constraint holds:

$$
\begin{aligned}
&-(A_t^S - A_{t-1}^S)\ \text{(net lending)}\\
&= \mathrm{t}_t^{WS}(W_t L_t^w + \xi W_t L_t^r)\ \text{(income tax revenue)}\\
&+\mathrm{t}_t^{K}\Pi_t\ \text{(corporate income tax revenue)}\\
&+\mathrm{t}_t^{C} P_t^C C_t^F\ \text{(indirect taxes)}\\
&+\mathrm{t}_t^{FS} W_t L_t\ \text{(firms' social security contributions)}\\
&-P_t^C C_t^S\ \text{(state consumption)}\\
&-\mathbf{T}_t^S\ \text{(total net transfers)}\\
&-r_t A_{t-1}^S\ \text{(interest payments)}
\end{aligned}
\tag{32}
$$

Accordingly, the fiscal balance of public pension funds consists of pension contributions levied on wage income. Pensions are financed by collecting pension contributions from firms and workers as well as from revenue from pension funds. The overall pension contribution rate is $\mathrm{t}_t^P = \mathrm{t}_t^{FP} + \mathrm{t}_t^{WP}$, with separate rates for employers' and employees' contributions. Pensions to retirees

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[37] In practice, separation is well-grounded also because administration of pension funds is usually independent from the central government. For example in Finland pension policy is quite independent from other public administration and fiscal policy setting. Even though the govenment in the end makes formal decisions on contribution rates, pension funds are de facto governed by an entity outside the government consisting of three parties: labour union, nsurance companies and the government. For more detailes see Finnish Centre for Pensions (2007).

total T_t^{PR} and include, besides old age pensions, disability pensions and other pensions. Pension funds accumulate financial assets A_t^P .

In each period the following flow budget constraint holds for the pension fund:

$$\begin{aligned}
&-(A_t^P - A_{t-1}^P) \text{ (net lending)} \\
&= \mathrm{t}_t^P W_t L_t \text{ (social security contributions of employer and employee)} \\
&-\mathrm{T}_t^{PR} \text{ (total transfers paid to retirees)} \\
&-r_t A_{t-1}^P \text{ (interest payments)}
\end{aligned} \tag{33}$$

4.2.2.2 Fiscal rules

The model is closed by the tax rule and contribution rate rule set separately for the state and the public pension funds. Fiscal targets are set to maintain sustainability in terms of the SGP requirement for general government finance.

The state targets the debt/GDP ratio and adjusts the labour income tax rate to stabilize debt at the targeted level within a 'proper' time horizon. The fiscal rule is of tax difference type [38]:

$$\Delta\tau_t^{ws} = \theta_1 (A_t^S - \overline{A}^S)/Y_t + \theta_2 \left[\Delta(A_t^S - \overline{A}^S)\right]/Y_t \tag{34}$$

where $\overline{A}^S / Y_t$ is an exogenous target for the actual indebtedness ratio. If the government spending ratio is exogenous, the debt will also render the steady state tax rate exogenous, in effect determined unambiguously by the debt ratio. The parameters θ_1 and θ_2 determine the speed of adjustment. In the benchmark simulations, the debt ratio is a constant set at the steady state value of 0.5. Values of the adjustment parameters were set at θ_1 =0.08 and θ_2 =0.9, which cause the debt ratio to proceeding smoothly to the target within the period of demographic changes.

Using the same analogy, the pension contribution rate is targeted at the pension funds to wages ratio. Formally,

$$\Delta\tau_t^P = \theta_1 (A_t^P - \overline{A}^P)/W_t L_t + \theta_2 \left[\Delta(A_t^P - \overline{A}^P)\right]/W_t L_t \tag{35}$$

where $\bar{A}^P/\ W_t L_t$ is the target level for the pension fund. In benchmark simulations, we set

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[38] See the discussion of Mitchell, Sault and Wallis (2000) on the properties of fiscal rules in macro models. See also Railavo (2004) for a discussion of alternative fiscal policy rules and their stability properties.

$$\overline{A}^P / W_t L_t = \varphi_t / \varphi_{t-1} * A_{t-1}^P / (W_{t-1} L_{t-1}) + (1 - \varphi_t / \varphi_{t-1}) * \overline{A}^P / (W_t L_t) \tag{36}$$

where φ_t is old age dependency ratio and $\overline{A}^P / W_t L_t = 1.6$ is the targeted value of the pension fund relative to the wage sum in the steady state. The faster the change in the dependency ratio, the slower the funding rate will approach the target.

Altogether, in our benchmark, given targets will bring the net debt of general government to about 20 per cent of GDP, which represents the sustainability ratio of unchanged net debt position that is applied as a sustainability criteria of in the framework of public surveillance in the EU.

4.2.2.3 Production

The supply side is based on a production structure where domestic intermediate goods are combined with imported intermediate goods to produce final goods, broken down into consumption goods, capital goods and export goods. Producers of intermediate goods combine labour and and capital using CES production technologies with factor-augmenting technical trends exogenously given. The production differs across final goods in terms of elasticity of substitution.

Production of Intermediate Goods

The production function for intermediate goods, $Y_t(j)$, is

$$Y_t(j) = \left[\delta\left(\Lambda_t^K K_t\right)^{-\rho} + (1-\delta)\left(\Lambda_t^L L_t^F\right)^{-\rho}\right]^{-1/\rho}.$$

where K_t is capital, L_t^F labour, parameters Λ_t^K and Λ_t^L denote time-varying capital and labour-augmenting technical progress respectively, $1/(1+\rho)$ is elasticity of technical substitution with ρ the substitution parameter and δ the share parameter in the production function. The technical change is labour-augmenting on the balanced growth path.

Cost minimization implies the following real marginal costs:

$$\frac{MC_t(j)}{P_t(j)} = \left[\delta^{\frac{1}{1+\rho}}\left(\frac{R_t}{\Lambda_t^K P_t(j)}\right)^{\frac{\rho}{1+\rho}} + (1-\delta)^{\frac{1}{1+\rho}}\left(\frac{W_t^F}{\Lambda_t^L P_t(j)}\right)^{\frac{\rho}{1+\rho}}\right]^{\frac{1+\rho}{\rho}},$$

where R_t denotes the nominal rental price of capital services and $W_t^F = (1+t_t^F)W_t$ represents nominal labour costs including employers' pension and social security contributions.

In the steadystate, prices $P(j)$ are determined by the markup, $\Upsilon(=-\frac{1}{\rho^z})$ over marginal costs:

$$P(j) = \Upsilon MC(j) \tag{37}$$

The first order conditions (in logs) with respect to capital services and labour are given by

$$r_t - p_t = \log\delta - \log(\Upsilon) - \rho\log\Lambda_t^K + (1+\rho)(y_t - k_t) \tag{38}$$

$$w_t^F - p_t = \log(1-\delta) - \log(\Upsilon) - \rho\log\Lambda_t^L + (1+\rho)(y_t - l_t). \tag{39}$$

The aggregate pricing equation for intermediate goods producers, assuming Calvo pricing, is of the form

$$\Delta p_t = \beta E_t \Delta p_{t+1} + \Xi\left[\upsilon + mc_t - p_t\right] \tag{40}$$

where Ξ captures the frequency of price changes . Inflation is determined by expected inflation and log markup υ over the real marginal costs $mc_t - p_t$.

Production of Final Goods

Final goods producers combine domestic intermediate inputs and imported goods. Producers take the market price for their products as given, since product markets are set to be competitive. The demand for retailers' output is given by consumption and investment of the private and general government sectors. The output of the consumption-goods retailer divides into the private consumption and public purchases of market goods, $C_t^T \equiv C_t^H + C_t^{SF}$. The capital-goods retailer faces similar demand comprising private sector and public sector investment, $I_t^T \equiv I_t + I_t^S$.

The production technology for consumption and investment goods is:

$$Q_t^j = \left[\delta^j\left(Y_t^j\right)^{-\rho^j} + (1-\delta^j)\left(M_t^j\right)^{-\rho^j}\right]^{-1/\rho^j}, \quad j = I, C^T$$

δ^j is the respective share parameter and ρ^j the respective substitution parameter $(\sigma^j = 1/(1+\rho^j))$. M^j denotes imports and Y^j the domestic intermediate good. Cost minimization generates following price indices,

$$P_t^j = (1-t_t^c)^{-1}\left[(\delta^j)^{\frac{1}{1+\rho^j}}\left(P_t\right)^{\frac{\rho^j}{1+\rho^j}} + (1-\delta^j)^{\frac{1}{1+\rho^j}}\left(P_t^{Mj}\right)^{\frac{\rho^j}{1+\rho^j}}\right]^{\frac{\rho^j+1}{\rho^j}}$$

and conditional factor demands

$$Y_t^j = \left(\delta^j\right)^{1+\rho j}\left(\frac{P_t}{(1-\mathrm{t}_t^c)P_t^j}\right)^{\frac{-1}{1+\rho^j}} Q_t^j$$

$$M_t^j = (1-\delta^j)^{1+\rho^j}\left(\frac{P_t^{Mj}}{(1-\mathrm{t}_t^c)P_t^C}\right)^{\frac{-1}{1+\rho^j}} Q_t^j .$$

The consumption-goods producer (retailer) pays the indirect taxes, t_t^C . Hence the tax base for indirect taxes consists of private consumption and government purchases. No indirect taxes are levied on investment goods.

The exporter is a firm that combines domestic intermediate input, Y_t^X, and imported raw materials, M_t^R, to produce export good, X_t, in competitive markets. Technology and preferences are identical to those of the retailers.

Capital rental firms

Production capital is modelled as a homogeneous factor of production that is owned by a firm that rents capital to producers of domestic intermediate goods. The capital rental firm operates under perfect competition. Physical capital accumulation generates real adjustment costs in the form of lost capital stock. Capital accumulation is given by

$$K_t^p = I_t - \mathsf{S}\left(K_t^p, K_{t-1}^p, K_{t-2}^p\right) + K_{t-1}^p\left(1-\delta_K\right) \tag{41}$$

where $\mathsf{S}(\cdot)$ denotes adjustment costs of physical capital stock and δ_K is the capital depreciation factor. The capital rental firm maximizes its expected discounted profits

$$\max_{\{I_t\}} E_t \sum_{s=0}^{\infty} M_{t,t+s} \Pi_{t+s}^K \tag{42}$$

subject to the capital accumulation equation (41) and the definition of capital services[39], $K_t = K_{t-1}^p$. Its momentary profits are given by

[39] For simplicity we assume that capital services obtain a lagged value of physical capital stock. In a more general case capital services would depend also on the endogenous utilization rate. This extension alters the results only in business cycle frequencies and is thus beyond the scope of this study.

$$\begin{aligned}\Pi_t^K &= R_t K_t - P_t^I I_t \\ &= R_t K_{t-1}^p - P_t^I \left(K_t^p + \mathsf{S}_t(K_t^p, K_{t-1}^p, K_{t-2}^p) - K_{t-1}^p(1-\delta_K)\right)\end{aligned} \tag{43}$$

The price index for investment goods, P_t^I , is the price index of the domestic investment good retailer and R_t denotes rental rate for capital. Future profits are discounted using the nominal stochastic discount factor (pricing kernel) $M_{t,t+s} = \beta^s U'(C_{t+s}) P_t^C / [U'(C_t) P_{t+s}^C]$. The first order condition with respect to capital stock K_t^p is given by

$$\begin{aligned}&-P_t^I E_t\left[1+\mathsf{S}_t'(K_t^p, K_{t-1}^p, K_{t-2}^p)\right] \\ &+E_t M_{t,t+1}\left\{R_{t+1} - P_{t+1}^I\left[\mathsf{S}_{t+1}'(K_{t+1}^p, K_t^p, K_{t-1}^p) - \left(1-\delta^K\right)\right]\right\} \\ &-E_t M_{t,t+2}\left[P_{t+2}^I \mathsf{S}_{t+2}'(K_{t+2}^p, K_{t+1}^p, K_t^p)\right] = 0.\end{aligned} \tag{44}$$

Due to the end-of-period timing of physical capital stock, the accumulated physical capital is in use in the following period. Hence, the expected following period's rental rate, R_{t+1}, governs the current period investment decision. The adjustment cost function is quadratic in changes of the physical capital stock:

$$\mathsf{S}_t(.) = \frac{\gamma_1}{2}\frac{\left(\Delta K_t^p - \gamma_2 \Delta K_{t-1}^p\right)^2}{K_{t-1}^p}. \tag{45}$$

The usual `investment equation' can be obtained by substituting the parametric version of adjustment costs for the share parameter in the first order condition.

4.2.3 Market Equilibrium

All markets are in equilibrium in every period. The capital goods market is in equilibrium when the supply of capital services by the capital-rental firm equals the demand for capital services by intermediate goods producers. Similarly, the labour markets are in equilibrium when the demand for labour equals its supply, $L_t^s = L_t^D$. In the intermediate goods sector, the demand for intermediate goods by retailers and exporters equals total supply:

$$Y_t^C + Y_t^I + Y_t^X = Y_t. \tag{46}$$

Markets for final goods clear when

$$C_t^S + C_t^H = C_t^T$$
$$I_t^G + I_t = I_t^T$$
$$\left(\frac{P_t^X}{S_t P_t^W}\right)^{-\rho^W} M_t^W = X_t, \tag{47}$$

where P_t^W is the aggregated export price of competing economies and M_t^W is aggregate imports of export markets. When the market clearing conditions hold, the workers' and pensioners' budget constraints (7) and (13), the general government budget constraint (36) and the pension fund's budget constraint (37) imply the following equation for the accumulation of foreign assets:

$$S_t A_t^W = (1 + r_t^F) S_t A_{t-1}^W + \underbrace{P_t^X X_t - P_t^{MR} M_t^R - P_t^{MC} M_t^C - P_t^{MI} M_t^I}_{\text{trade balance}} \tag{48}$$

The current account balance is given by $S_t(A_t^W - A_{t-1}^W)$ and the factor income account by $r_t^F S_t A_t^W$.

4.2.4 Key model parameters

The following model's key parameters are calibrated to reflect the main features of the Finnish economy[40].

Table 1 Key model parameters

Households

β	Subjective discount factor, parameter	0,99
υ	Elasticity of periodic utility wrt consumption	0,80
σ	Inter-temporal substitution elasticity, parameter	0,45
ξ	Labour efficiency of retirees, parameter	0,30
ϵ	Relative marginal prospensity to consume, variable	1,59
π	Worker's marginal prospensity to consume, variable	0,019
Ω	Additional discounting factor	1,10
$\bar{\nu}^w$	Elasticity of workers' labour supply, variable	0,26
$\bar{\nu}^r$	Elasticity of pensioners' labour supply, variable	0,23

[40] Calibration principles are described and discussed in detail in Kilponen and Ripatti (2006).

Production

$\hat{\Lambda}_L$	Labour-saving technical change p.a., parameter	2,08
δ^K	Capital depreciation rate, parameter	0,08
Υ	Price markup, parameter	1,08
$\overline{A}^F / \overline{\Gamma}$	Price to equity ratio, variable	15.0
δ	Capital's share, parameter	0,10
ρ	Elasticity of substitution between capital and labour	0,72

Public Finances

θ_1	Fiscal rule adjustment, parameter	0.08
θ_2	Fiscal rule adjustment, parameter	0.90
a^S	Central government debt (% of output)	0.50
a^P	Pension funds (% of wage bill)	1.70
c^S	Public consumption (% of output)	20.8
$\mathbf{T}^{SW}$	Transfers to workers (% of output)	6.40
τ^K	Corporate tax rate %, parameter	19.2
τ^C	Sales tax rate %, parameter	21.0

Real interest rate

$\overline{R}^F / \hat{P}^c$	Real interest rate, p.a., variable	2,40

Given our interest in distortionary effects of taxes, the crucial parameter affecting our results is the periodic utility of consumption, which determines the labour supply elasticities. The elasticity of utility is calibrated at 0.80 and it produces uncompensated labour supply elasticity values of 0.23-0.26. This is broadly in line with elasticities applied in the standard European models. Elasticity of labour supply is of course highly uncertain. Concerning the ageing issues, some authors have argued that European elasticities could be much higher if, for example, all the ways in which taxes affect labour-supply decisions of retirees were taken properly into account[41]. An actuarially unfair defined benefit system, in particular, tend to raise the implicit tax rate for a retiree. High tax rates also create incentives for early retirement. Unfortunately, our model setting does not allow us to investigate these impacts. In principle for Finland, where mandatory public pension scheme is exceptionally extensive and tax-benefit links are particularly weak, the calibrated values of labour supply elasticities can be considered conservative.

4.3 Simulations

4.3.1 Benchmark economy

The benchmark for simulations is an economy where demographic changes have already passed through to the economic structure, e.g. labour market, production and public finances. After demographic shock, the economy grows along a new steady state growth path where the old age dependency ratio is permanently higher than in the initial steady state without ageing. The demographic shock is calibrated using parameters for the dependency ratio and probability of death to closely represent the situation Finland is facing.

Public finances are sustainable in terms of the SGP definition with government net debt remaining unchanged in the long term[42]. The wage tax rate and pension contribution rates adjust to keep the state debt and pension funds at the currently prevailing level in relation to GDP or wage bill. Other tax parameters, as well as government consumption as a share of GDP are assumed to remain unchanged.

Table 2 presents the main fiscal and macroeconomic variables at the steady state before and after a permanent demographic shock.

[41] According to Jacobs (2008) uncompensated elasticity of tax base could double in Europe if besides labour supply, also retirement and learning are endogenised.

[42] More precisely, the sustainability condition represents sustainability with the S2 indicator fulfilling the intertemporal budget constraint over an infinite horizon.

Table 2 Public finances, labour market and households' welfare: The steady state in the economy without ageing and in the aged economy (benchmark)

	Without ageing	Aged economy
Income tax rate % of workers, implicit	29.2	39.9
Pension contribution rate (firms and workers), implicit	19.9	27.0
Pension expenditure (% of output), variable	11.3	15.0
Employment rate, workers	0.75	0.61
Employment rate, retirees	0.17	0.32
Output growth, %	2.20	1.70
Private consumption per capita	4.70	4.00
Distribution of financial asset wealth, variable	0.17	0.25
Capital-output ratio	1.93	1.92
Net foreign assets % of output	-21.1	35.6

Under unchanged government net funds, reflecting the steep increase in the old age dependency ratio, labour tax rates had to increase altogether by about 17 percentage points in the long term (table 2)[43]. Both the pension contribution rate and wage tax rate should increase. As a consequence, because of distortionary taxation, the employment rate of workers would be in the steady state much lower than under stationary demography. That dominates the overall employment developments. Retirees' employment rate increases slightly, which is due to the fact that retirees' desire to compensate a decline in after tax wealth dominates the negative effect caused by a decline in wage compensation. Also real growth will be slower, consumption per capita lower and retirees' share of financial wealth much larger than in the initial steady state. A more detailed description of ageing effects is reported in Kilponen, Kinnunen and Ripatti (2007).

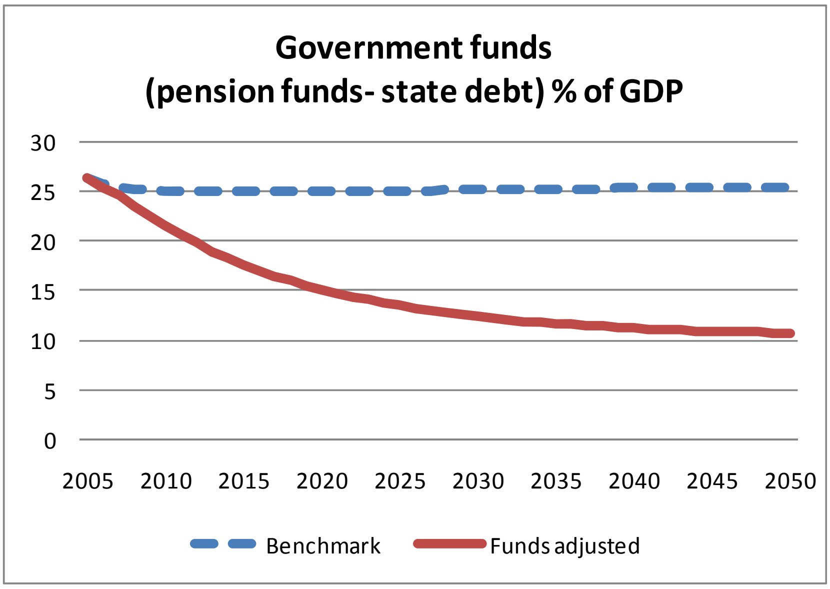
[43] Note that possible effects of pension reform were not included. According to Ministry of Finance (2007), the direct effect of ageing on general government would amount to 8 p.p. of GDP. Finnish Centre of Pensions estimates that pension contribution rate should be increased by 4 p.p.(see Biström et al.(2008)). Both institutions took reform into account.

Altogether, in the benchmark, sustainability of public finances requires large tax hikes. The tax burden should increase during the period when government is a net creditor in the financial market and the labour market is extremely tight.

4.3.2 Funding adjustments during demographic transition

In this section we consider government assets as an policy option in alleviating ageing stress. Simulation results are compared to the benchmark situation where government funds remain unchanged in relation to GDP. In the following simulations we change pension fund targeting in two ways: We endogenise funding rate to respond inversely to changes in the dependency ratio (see 38) and reduce the target fund-to-wage sum ratio from the current 1.7 to 1.4 after completion of demographic change by the end of the 2050s. The magnitude of targeted pension funds represents the level that would maintain sustainability of the public finances and would keep tax rates close the benchmark in the steady state. In terms of general government net assets to GDP, that means a decline from the prevailing level of 25 per cent of GDP to about to 10 per cent (Figure 1). Net lending of General Government would turn in to a slight deficit amounting to 1 percentage point of GDP at its highest at the beginning of the period. [44].

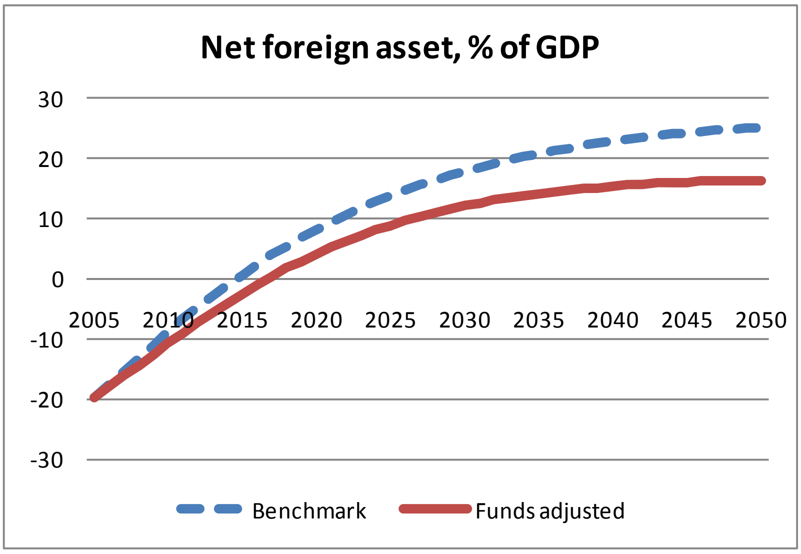
Figure 1 Adjustment in government funds



[44] Since under normal assumption the real interest rate exceeds the real growth rate, reducing funding will weaken pension fund balances and cause contribution rates to increase later.

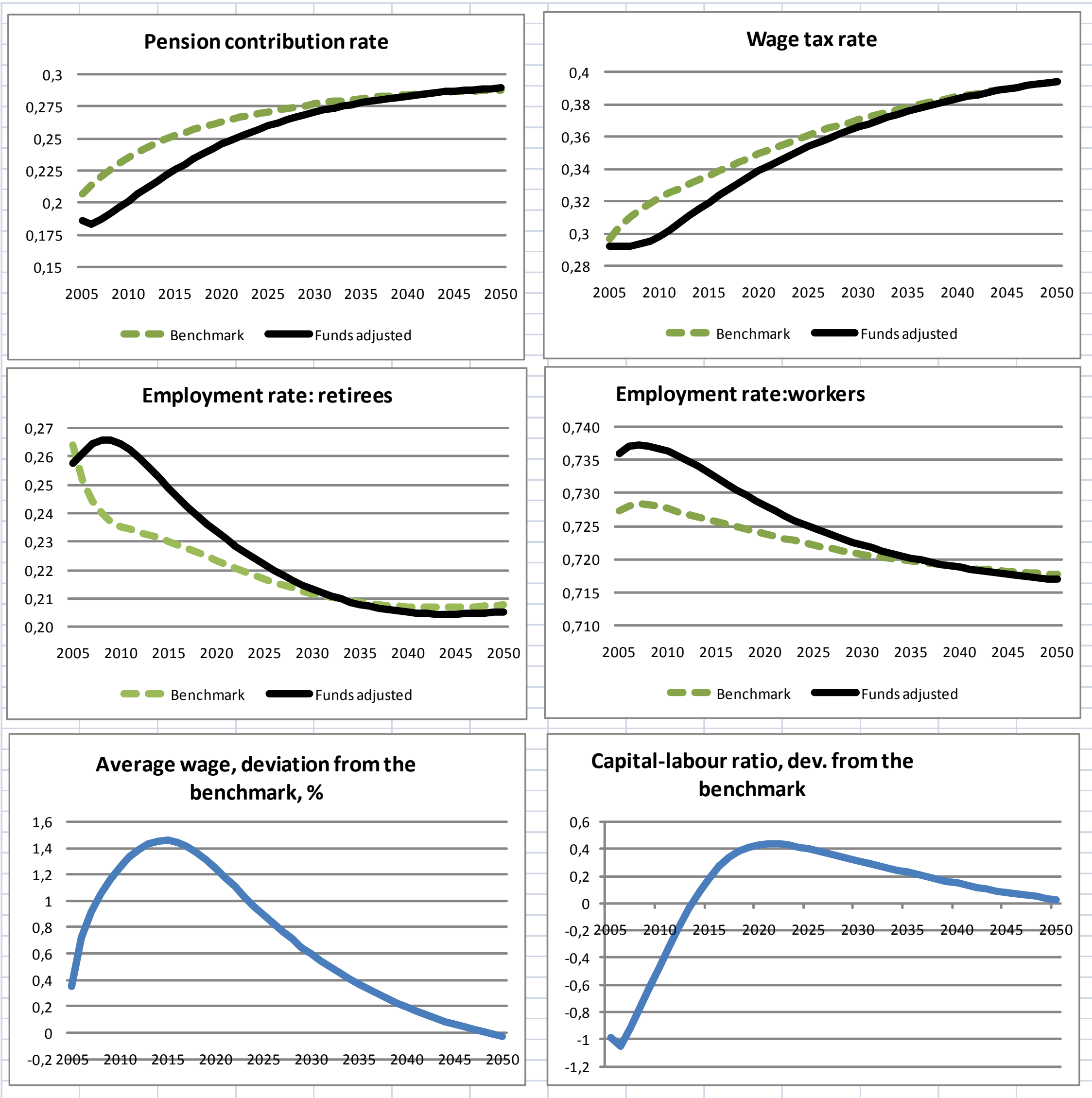
Given the small open economy environment with fixed interest rates, the counterpart of the weakening of the general government financial position is in net foreign financial assets. A reduction in government assets means that the current account surplus declines due to lower national saving. Net foreign assets decline by about 10 percentage points as a consequence of fund run-down in the long run (Figure 2).

Figure 2 Foreign net assets in the benchmark and simulation



The top panel of figure 3 shows that the slowing of pension fund accumulation would clearly ease the tax burden on labour. The need to raise the pension contribution rate remains about 3 percentage points lower up to 2020 and the increase in wage taxes would remain about 2 percentage points smaller during the same time. The difference versus the benchmark in overall tax burden on labour peaks to 5.5 percentage points at the midpoint of the 2020s. Pension contribution rates could stay lower than in the benchmark also for quite a long time, covering the entire period of demographic transition. In our experiment, tax rates actually do not reach the benchmark level until after four decades.

Figure 3 Results of an experiment where funding rate declines

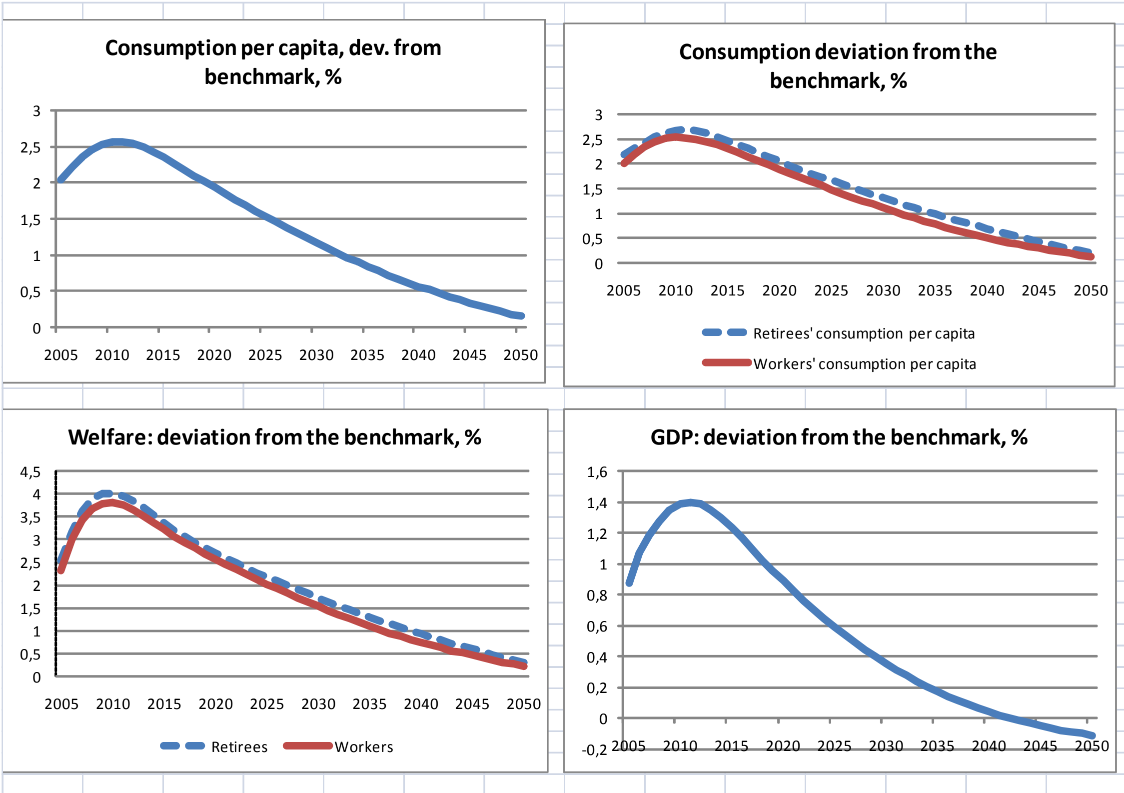


Labour market reactions to lower tax rates indicate substantial employment gains (second and third panel of Figure 3). The employment rate of workers would be nearly one percentage point higher on average during the next 15 years and retirees' employment would improve even in absolute terms as a reaction to a tax cut. Retirees' labour supply reacts stronger than workers' reflecting a wage set-up for the model with retirees reacting along their labour supply curve. Workers' employment reactions are more subdued because an increase in average wage will reduce labour demand. Due to the increase in average wages and labour supply, the capital-labour ratio declines after a tax cut but increases later on, at around 2015.

A lower tax burden increases the present value of the net human capital as well as social security wealth, since pension benefits are subject to income taxation (Figure 4). Improved wealth boosts consumption and labour demand. The consumption level would stay during the demographic transition about 2 percentage points above the benchmark. GDP real growth will exceed benchmark by more than 1 percentage point on average during the same period. This represents substantial economic gains for the economy.

The model with heterogeneous agents allows us to consider intergenerational effects of fund adjustment. Figure 4 shows that consumption of retirees constantly rises a bit more than that of workers. Retirees and workers differ with respect to planning horizon and combination of wealth. Retirees' shorter planning horizon means that any policy changes that affect their net present value of wealth is smoothed over a shorter period than that of workers. This and retirees' larger marginal propensity to consume out of wealth lead them to respond more strongly than workers to tax changes. But lower funding has practically no effect on income distribution. Welfare measures confirm the overall result. During the transition period, both retirees and workers are better off with rather similar welfare gains amounting to 1-2 per cent (Figure 4, bottom panel).

Figure 4 Results of an experiment where funding rate declines



4.3.3 Sensitivity analysis

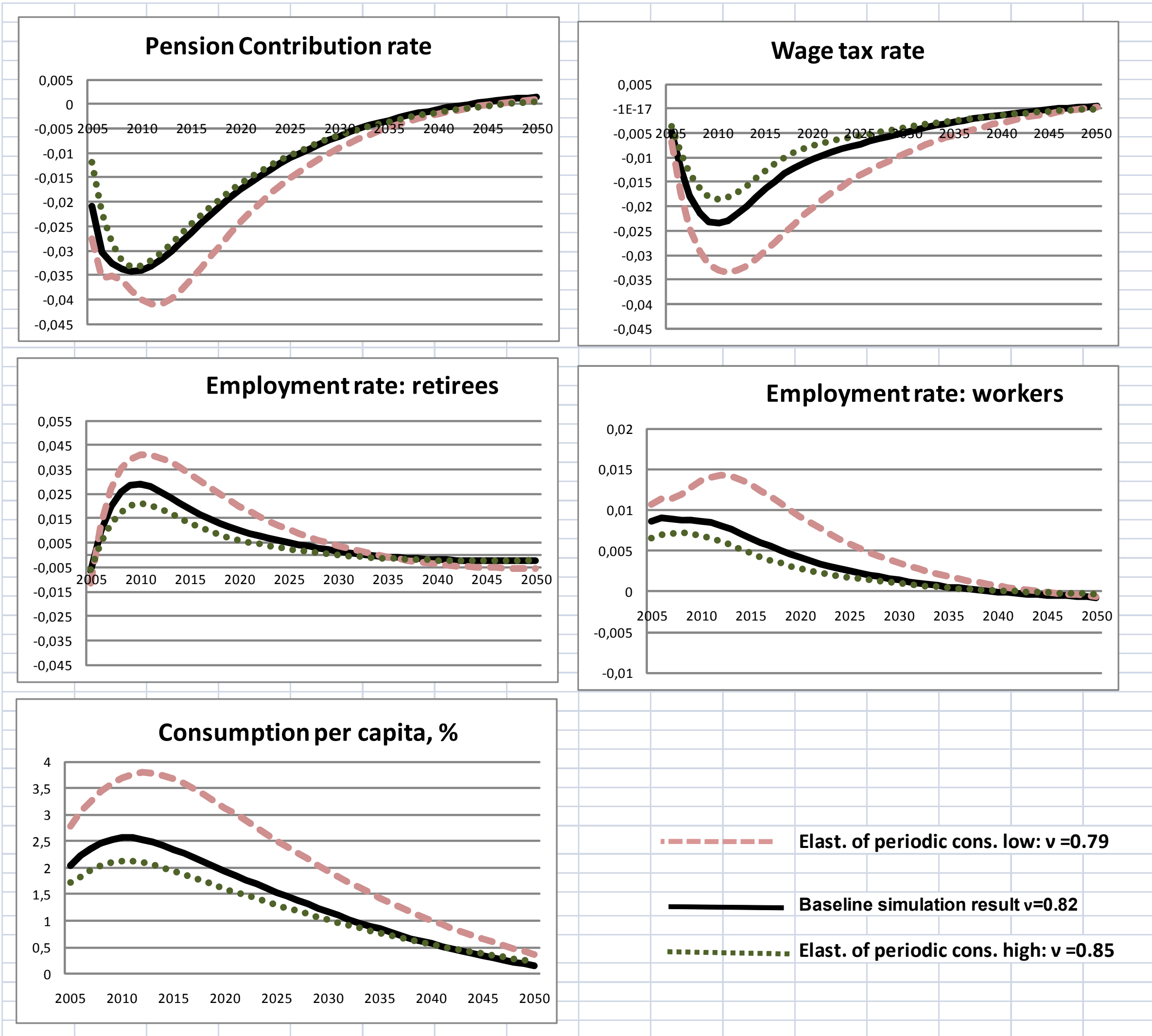
In sensitivity analysis we used alternative assumptions of some key parameters of the model. We conducted the same simulation experiment allowing parameter estimates to vary around the values used in the base simulations[45].

First we set the periodic elasticity of consumption, v, at slightly higher or lower than in the benchmark. Fund adjustments are particularly sensitive to cuts in the elasticity parameter (Figure 5). In particular, a lower elasticity value strengthens the labour supply reaction (see 29 and 20). Then lower funding with a lower tax rate gives a stronger boost to labour supply, allowing for larger tax reductions. This also improves after tax wealth compared to the benchmark simulations and

[45] The chosen procedure was not quite accurate since the balanced growth paths were not controlled for. If steady state values change substantially, due to parameter changes, then the analysed deviation from benchmark might not be guite comparable. This bias seems to relate to low values of the parameter v and particularly the reactions of retirees' participation. The employment rate of retirees gets quite different initial and final steady state values with a lower parameter value than in the benchmark.

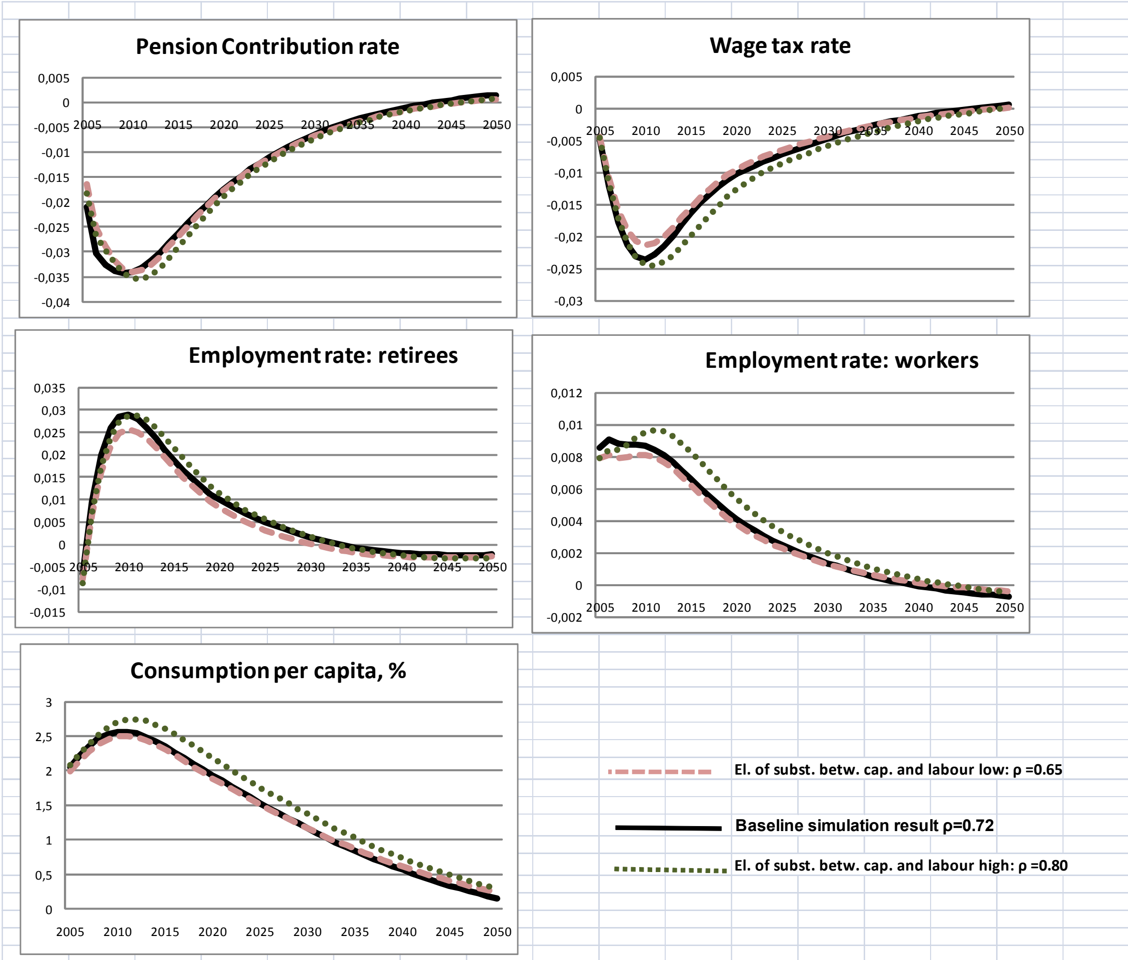
can be seen to have larger effect on consumption per capita. Instead, an increase of the same magnitude in the elasticity of consumption would make hardly any difference compared to the benchmark (see Figure 5).

Figure 5 *Alternative reactions on funds adjustment: elasticity of periodic utility of consumption varies*



Secondly, we varied the intertemporal elasticity of substitution parameter, σ. Figure 6 indicates only a slight variation in tax rates, employment and consumption. Lower values for the IES parameter, when households are slightly more willing to allow consumption to vary over time, brings foreword slightly the gains of funds adjustment in terms of consumption per capita.

Figure 6 *Alternative reactions on funds adjustment: Intertemporal elasticity of substitution (IES) varies*



Finally, the elasticity of substitution between capital and labour, ρ was varied. A noticeable effect is that, with a higher elasticity of substitution, employment of workers improves a bit more but somewhat later then in the benchmark (Figure 7). If capital and labour are more readily substitutable, lower pension contribution rates for employers induce them to demand more labour (see e.g. 41).

Figure 7 *Alternative reactions of the adjustment: Elasticity of substitution between labour and capital varies*

Besides uncertainties associated with parameter values, important risks are naturally related to demographic trends. Using stochastic population forecasts for Finland, Lassila and Valkonen (2008) reported substantial variations in forecasts. For example, they found a 50 per cent probability that the number of prime age workers in Finland is between 2.4 million and 2.8 million. Uncertainty as to aggregate labour supply however increase with a long lag when the fertility risk is realised, which will take place after 2-3 decades.

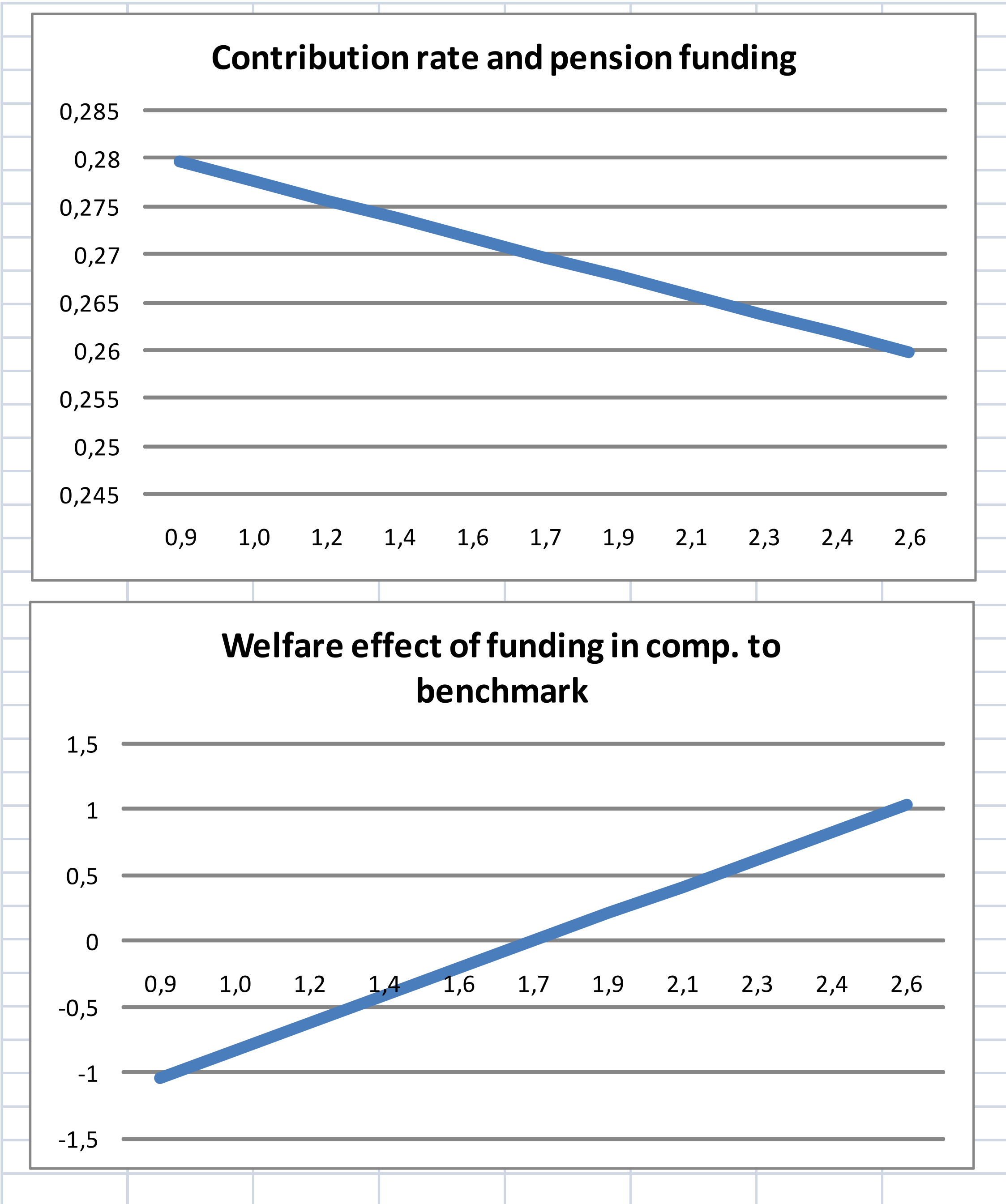
4.3.4 Steady state results

The simulation experiment shows that ageing costs can be lowered by adjusting funding rate to smooth tax reactions during the transition period of demographic change. In the long term, there exists a lower level of funding rate that produces the same welfare level and tax rates than in the benchmark economy where funding rate was assumed to remain unchanged. Table 3 shows that in the steady state the levels of labour taxation, employment, consumption and welfare remain practically the same as in the benchmark, even though some 20 percentage points of GDP less financial resources were devoted to pension funding. This is because smaller tax increases than in the benchmark led to a slightly lower wage level thereby making the production structure slightly more labour intensive. A lower wage level also means lower pension benefits compared to the benchmark. Consequently, the property income of pension funds will cover a larger share of pension payments, which helps to reach the benchmark welfare and consumption levels with smaller prefunding. Note also that, even under larger fund adjustments, tax rates and welfare effects remain quite modest (Figure 8). For example, moving from a pure PAYG system to current funding level would lower the tax ratio by only some 2 percentage points. This would reduce the welfare of consumers by about 1 percentage point.

Table 3 Long term effect of funding adjustment

	Steady states	
	Benchmark	Lower funding
Pension funds, % of wage bill	1.70	1.40
State debt, % of GDP	0.50	0.50
Pension contribution rate	27.0	27.4
State taxes	39.9	40.1
Employment rate, workers	0.61	0.61
Employment rate, retirees	0.32	0.33
Wealth distribution	0.245	0.245
Consumption per capita	3.976	3.954
Welfare, workers	0.00346	0.00345
Welfare, retirees	0.00266	0.00264
Capital-output ratio	7.87364	7.86974

Figure 8 *Reactions of welfare and pension contribution rate on funding adjustment in the steady state*



4.3.5 Discussion of Results

In the above analysis the lack of a tax-benefit link is crucial. Changes in contribution rates do not affect expected pension benefits, which, at the individual level, depend only on accrual parameters and past wages. Distortions from the labour market are of key importance for our results. In the related literature on pension policy, the degree of actuarity has typically been pinpointed as a crucial condition for macroeconomic reactions and intergenerational income distribution. If adjustments in pension parameters would directly affect individual pension benefits, it would render contribution payments similar to investments in annuities. Any policies that improve the actuarial rate will then lessen the distortionary effects of the pension system. For example Fischer and Keuschnigg (2007) found that reforms that strengthened the tax-benefit link clearly stimulated labour supply, even though the responses of older workers and prime age workers went in opposite directions. Even in a DB pension scheme, changes in contribution rates do not entail efficiency losses if the benefits change accordingly. Jaag, et.al. (2007) also reported pronounced economic gains from Austrian pension reform, which greatly improved the actuarity of the pension system. Also Nickel, Rother and Theophilapoulou (2008) found that steady state consumption improved under a policy package comprising a cut in pension level and a cut in proportional corporate taxes. Supply side gains from lower tax distortions boosted long term gains by changing factor prices.

In the present study, despite prefunding, there is no direct link between fund return and pension benefit. In other words, the size of pension fund affect households' social security wealth only through changes in contribution rates. An individual's benefit at retirement depends, not on the performance of asset prices during that time, but on his earnings during his working years. Unlike in an investment-based system, the actuarial present value of benefits is not equal to that of social security savings. Consequently, funding affects distortions only to the extent that it reduces pressures for contribution rate hikes. This contrasts with the literature of pension funding, where typically economic gains from funding have been found to come from a reduction in distortions. For example, according to Feldstein (2005), deadweight losses from social security insurance could clearly be diminished by moving towards an investment-based funding system. On the other hand, the result extends that of Guest (2008) who considered tax smoothing effects under tax distortions. Guest reported lifetime utility gains for future generations that would outweight the losses to current generation available by smoothing tax by funding. Our results indicate that under tax distortions, further gains are available if funding rate would be adjusted to respond large demographic shocks.

4.4 Conclusions

Given the growth in the old-age dependency ratio, ensuring sustainability of public finances requires a substantial increase in tax burden or a down-grading of social security in most European countries. This burden differs by country, depending on timing of ageing, coverage and generosity of the public pension scheme, as well as the degree of prefunding. Our experiment highlighted the use of the option of adjusting public funds in Finland where ageing problems are more severe than in any other European country, but where, on the other hand, quite focal policy measures have already been taken to prepare for ageing stress. In this paper already collected public funds were used as an additional policy option to alleviate the costs tax hikes pose for the economy during the transition to an older population structure. The analytical tool was the DSGE model, which features the Finnish pension scheme with defined benefit, high but collective funding and tax distortions.

A simulation experiment illustrates that, during the transition to an older population structure, ageing costs can be lowered allowing the decline in public funds to smooth the tax reactions. Lower tax rates stimulate labour supply when the labour market is tight. Easing the funding target leads to a slower growth in the costs of labour, better employment and faster production growth. Given the collective nature of pension funding, a reduction in funding redistributed welfare between retirees and workers. Altogether, the experiment indicated quite substantial gains achievable with a funding adjustment during demographic transition. Since interest rate reactions were absent in the open economy, even temporarily lower taxation could change factor prices thereby rendering the production structure more labour intensive. In the experiment, the funding rate could be lowered by 20 percentage points of the wage bill without any losses in welfare.

As discussed in this paper, Finland's public pension scheme is unique in many respects. Still, our experiment highlights issues common to all public pension schemes. Concerning efforts to increase public pension funding in other European countries, the long term costs of funding depend on how funds could be used to smooth ageing pressures. In most European countries, the old age dependency ratios start to accelerate in about 20 years time, which means that pension funds, could be accumulated before the labour market becomes extremely tight. This creates room for fiscal policy to alleviate labour shortages when ageing stresses are at their highest level.

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5. Assessing the sustainability of health and long-term care financing
- and the usefulness of policy guidelines based on demographic forecasts

Jukka Lassila, Tarmo Valkonen and Juha M. Alho[46]

5.1 Introduction

Sustainability of public finances is essential for preserving the possibility to carry out sovereign fiscal policy. This prerequisite is emphasized when the policy objective is to run an extensive welfare state, as in Finland. The long-term fiscal sustainability of a welfare state is vulnerable especially to demographic risks.

Experiences show that a country can lose its fiscal autonomy for a long period of time due to lack of foresight and fiscal discipline. The welfare losses caused by fiscal crises can be large and their incidence arbitrary. Yet despite its importance, astonishingly little research has been done on fiscal sustainability under uncertainty. Long-term sustainability of public finances is regularly assessed by, e.g., the European Commission. The problem is that the accounting-based evaluations consider future uncertainty as an issue that can be managed by presenting a baseline scenario and some more or less *ad hoc* alternatives. These calculations also miss the potential feedback from high public debt to the economy. Quoting Leeper (2010), fiscal policy is based on alchemy and monetary policy on science.

We employ an improved method to evaluate the long term sustainability of fiscal policy under demographic uncertainty. We highlight how this method can be used to test a risk sharing rule that shifts the extra expenditure burden of very unfavorable demographics from municipalities to the state. More specifically, we assume that a ceiling is put on the average municipal tax rate. If demographic developments increase municipalities' health and long-term care expenditure more than allowed by this ceiling, the state finances the shortfall by debt. We also study cases where the government uses the information provided by demographic projections to prepare for bad future outcomes by reducing public indebtedness.

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We use 200 sample paths from a stochastic population projection as an input in an economic model to assess probabilistically the sustainability of public finances. The economic model is a numerical overlapping-generations model of the type originated by Auerbach and Kotlikoff (1987). We have previously tested various policy rules assuming that the realized sample path from a stochastic population projection is immediately observed by the agents of the model and followed with perfect foresight until death (Lassila and Valkonen, 2008). In the current study households and firms expect demographics to evolve according to forecasts. Each period a new population projection is generated and the agents re-optimize their decisions.

In the next section the economic model and the links between population projections and future public health and long term care expenditures are established. Section 5.2 also justifies our attention to demographic uncertainty by showing how radically population projections have changed during the last decade. The section also describes how forecast revisions can be embedded in stochastic population projections. Section 5.3 presents the baseline stochastic assessment of the sustainability of health and long-term care financing in Finland. In section 5.4, some policy alternatives and guidelines are studied. Section 5.5 concludes with key findings of the sustainability outlook and remarks on future developments of the approach used.

5.2 Modeling the economics and demographics of ageing Finland

5.2.1 The economic model

A thorough analysis of the interaction between public finance and population ageing necessitates the use of economic models that are able to fully use the rich information in population statistics and projections. The model should, e.g., be able to aggregate the reactions of the individuals, representing birth cohorts of various sizes, to total private consumption and labour supply. It should also encompass with sufficient preciseness the interaction between the population structure and public sector revenues and expenditure. Moreover, the model should describe the behavior of the individuals in situations that have not been experienced before, such as in case of living longer in the future.

Dynamic general equilibrium models, with overlapping generations of household, take into account the interaction between demographic structure and the factor markets of the economy, encompassing thereby implications of growth models. They can also produce outcomes with similar preciseness as actuarial pension models and generational accounts, since it is possible to model the pension system rules and detailed links between age of the household generations and public expenditures and revenues. They suit well to policy analysis, since households and firms react to policy. For the same reason, they are able to track the sensitivity of the public sector finances to variation in factors outside domestic policy's reach. The numerical models that satisfy these conditions can be classified as successors of the overlapping-generations model of Auerbach and Kotlikoff (1987).

We use in our simulations a model called FOG, which is based on the Auerbach - Kotlikoff model tradition. The model, which is described in more detail in, e.g., Lassila and Valkonen (2008), is modified to describe a small open economy and calibrated to the Finnish economy. The population projections with their embedded forecasts are used as inputs in the model.

The driving forces of the model economy are the transitions in the demographic and educational structure of the population and the trend growth of labour productivity. Population is ageing due to longer lifetimes, low fertility rates and the transition of baby boomers from working age to retirement. Educational level improves in the future since the current middle-aged generations have on average lower level of education than the young ones. Each household generation in the model is divided into three educational groups with different lifetime productivity profiles determined by empirical observations of recent wage profiles. The educational shares are supposed to develop in future in line with the official projections. This raises the average productivity of labour.

Public expenditures have strong connection to the age of individuals in the model. Provision of public services is allocated mainly either to the early years (day care and education) or to the last ten years (health care and old age care). Similarly, income transfers are distributed mainly either to young families or to retired individuals. This is why changes in the demographic structure are so important for public expenditures. We assume that all income transfers (except the earning-related pensions) are fully indexed to wages because any other assumption would have dramatic consequences to income distribution in the very long term analysis. Expenditure that is not age-related is assumed to grow at the same rate as the GDP.

The growing number of people in old age and near death increases the demand for health and old age care; this is described in subsection 5.2.2. We assume that these demography-driven additional services are produced by the private sector, but the public sector pays for all the production costs. These services are produced using labour and intermediate goods as inputs. There is no productivity growth in the production. The shares of employees in private and public sector are kept constant.

Public sector revenues originate from two types of sources. The majority of the receipts are accumulated by income taxes, consumption taxes and social security contributions. Another noteworthy revenue source is the yield of the public sector wealth. The yield of the wealth is important especially for the pension funds, but also the state has substantial financial assets. Some of the state's assets are less liquid and yield less than the market rate, such as loans of the Housing Fund of Finland. The lower liquidity may turn out to be a problem if the gross debt threatens to reach very high levels.

We assume that the modeled subsectors of the general government - the municipal sector, the public and the private sector pension fund, and the national social security institute – have their own budgets, which are balanced either by social security contributions or earned income taxes. The only exception is the state budget, which is balanced by borrowing. Earned income tax brackets are adjusted with the growth of the economy. The pension funds follow their current prefunding plans, and pension contributions are endogenous. Households are modeled to react to the income and substitution effects of taxes and social security contributions.

Labour input is determined partly by exogenous assumptions and partly by endogenous adjustments in the model. Exogenous factors are trend growth of labour productivity (1.75% per annum in private goods production), demographics, educational gains and unemployment. The model is calibrated so that the trend labour productivity growth and the following higher wages do not affect the otherwise endogenous labour/leisure choice of the households.

The FOG model consists of five sectors and three markets. The sectors are households, enterprises, the general government described above and a foreign sector. The labour, goods and capital markets are competitive and prices balance supply and demand period-by-period. There is no money or inflation in the model. The unit period is five years, and the model has 16 adult generations living in each period.

We assume that the pre-tax rate of return on saving and investments is determined in global capital markets. The country has, however, some monopoly power in the trade of goods, which makes the terms of trade endogenous. Foreign economies are assumed to grow with the trend growth rate of the domestic labour productivity. Real wage adjusts to equalize the value of marginal product of labour and labour costs in the private production (excl. private health care and LTC). The rest of the workers, who provide tax-funded services produced in the private and the public sector, earn the same wage.

In our analysis we substitute the perfect foresight assumption with an approach where decision makers sequentially optimize their behaviour according to revised demographic forecasts. We justify the use of a revised forecasts methodology by two viewpoints: First, it seems clear that households in reality do not take uncertainties related to their future contribution rates or benefits fully into account when making their savings and labour supply decisions. These uncertainties are very seldom discussed, let alone quantified, in e.g. the popular press. Second, by making the extreme assumption that households ignore these uncertainties altogether and base their decisions on deterministic forecasts, we avoid the difficulties related to general equilibrium heterogeneous agent models with aggregate uncertainty. This allows us to use a model that includes detailed descriptions of rather complex pension and other welfare systems.

5.2.2 Health and long-term care expenditure in ageing Finland

Some illnesses and injuries both hasten the death and increase the health and long-term care (LTC) costs in the last years of life. Thus when modeling the dependence of health and LTC expenditure on population and its age structure, it is reasonable to include also mortality as an explanatory variable. This can be used in long-term projections also, since population forecasts include also mortality, implicitly or explicitly.

Our starting point is Häkkinen *et al.* (2006), who used individual-level health and LTC expenditure for a large sample of persons in ages 65+ in 1998. According to their calculations, 49% of health expenditure and 75% of LTC expenditure went to persons who died in 1998 – 2002.

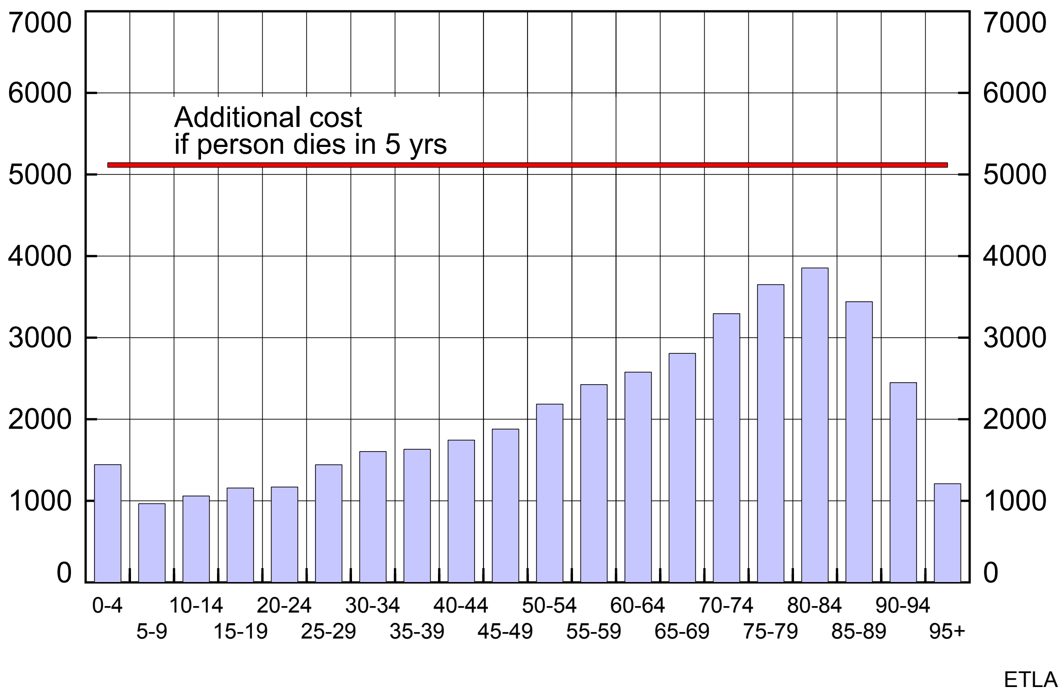
From these figures one can deduce that 51% of health and 25% of LTC expenditure was not directly death-related, because they occurred to persons that were still alive five years later. Furthermore, part of the expenditure for those who died obviously had no causal connection with death. A person who died because of lung cancer in 2002 may have been treated for a dislocated shoulder in 1998.

Using mortality data, we can estimate the share of expenditure occurring to those who die within five years, assuming that proximity to death has no effect on the expenditure. To do this by age group, we have to use also data for 2006, and implicitly assume that the per capita supply and unit costs of health and LTC services were the same as in 1998. The weighted average of this share, estimated over 5-year age groups for persons aged 65 and above, was 28% of health and 48% of LTC. These are smaller shares than Häkkinen *et al*. (2006) report. The difference in health expenditure share, 21%, can be interpreted as a lower limit for the health cost that proximity to death causes. A corresponding lower limit for LTC is 27%. Thus 21 – 49% of health expenditure and 27 – 75% of LTC expenditure has links to proximity to death.

Thus the Finnish data shows that there are costs that depend on the proximity to death and costs that do not depend on it. Assuming that the latter, within each age group, are on average the same per capita, we could calculate the share of the former. This was 29% in health expenditure and 51% in LTC expenditure. We modeled it to be the same per capita, irrespective of the person’s age. Thus the total expenditure depends both on the number of people in each age group and the number of people who will die within the next five years.

The results concerning health expenditure are presented in Figure 1.

Figure 1 Health care costs per capita at 2006 prices

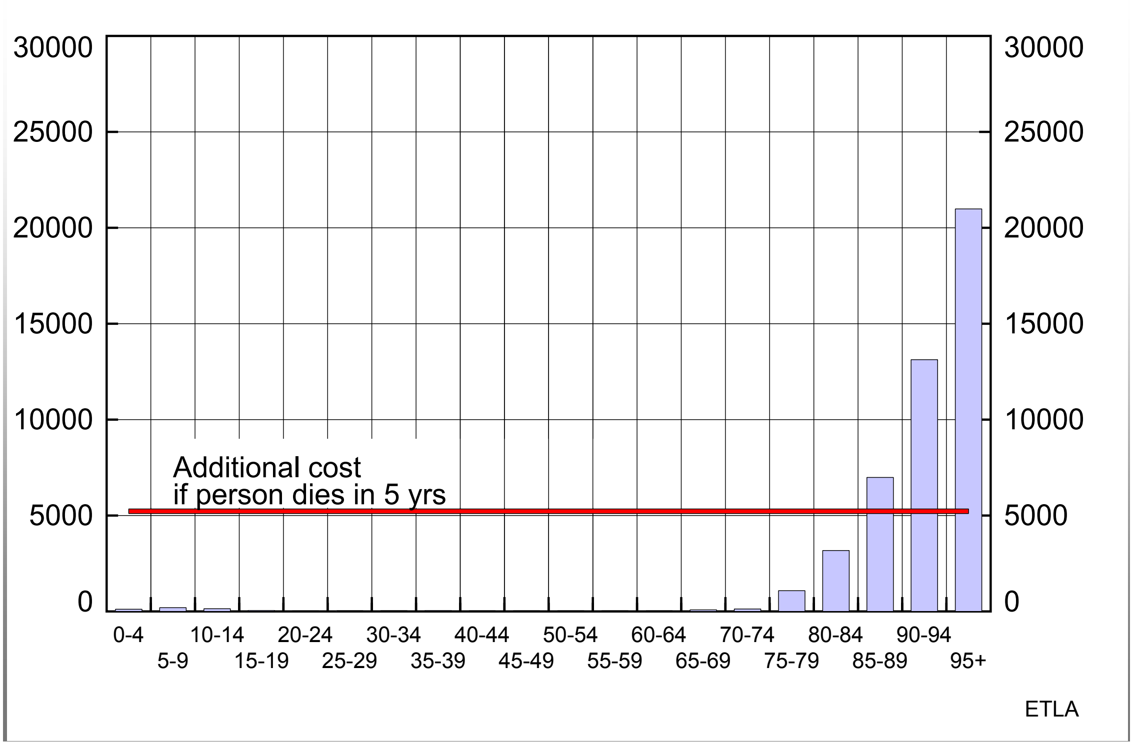


Average health costs per capita in different age groups vary between 1000 and 4000 €. Proximity to death causes an additional cost of about 5000 €. Since most deaths occur in old age, the total costs in old age groups are much higher than in young or middle-aged groups.

The corresponding results for LTC are in Figure 2 Proximity to death again causes an additional cost of about 5000 €, almost the same as in the case of health. The age profile of LTC costs is very different from health care. There are very small costs below age 75, but after that the costs rise rapidly and exceed 20 000 € for the oldest group.

Although per capita LTC costs are much higher than health costs in very old ages, aggregate health costs are higher than LTC costs, because the bulk of the population is in ages below 75.

Figure 2 *Long-term care costs per capita at 2006 prices*



Note also that the bars in Figures 1 and 2 can be thought of as costs of increasing life expectancy. If we had modeled the costs to depend entirely on age, then the average per capita costs would have been higher, and the costs of additional years in life expectancy would also have been higher. Our way of modeling in fact produces smaller total cost projections for Finland than alternative methods used by, e.g., the European Commission and the Ministry of Finance. We also exclude all cost effects related to improvements in the standard and availability of these services. Although cost-wise we are on the optimistic side here, our results show that financing these costs will not be unproblematic.

5.2.3 Forecasting demographic forecasts

To illustrate how long-term demographic forecasts can change substantially in a relatively short time, Figure 3 shows four forecasts, made between 2002 and 2009, for the future population in Finland. The total population was forecasted in 2002 to be about 5 million in 2050. The view has changed gradually, and the latest forecast is about 6.1 million in 2050. That means a 22 percent difference between forecasts made during seven years.

There were large and systematic changes also in the number of working-age population and the number of elderly. These changes can be traced back to changing views on fertility, migration and longevity. They have affected empirical sustainability evaluations in various ways. There are more people working (good for tax revenues), more retirees (costly for public finances) and people live longer (good for individual welfare but costly for public finances).

Figure 4 shows the forecasts for the number of people aged 65 and over. Although the changes have been significant, they all show the basic feature of an ageing society: the number is growing. The issue is quantitative – population is ageing but we don't know how much.

Statistical methods of expressing demographic uncertainty have been developed by many researchers (see e.g. Alho and Spencer, 2005). These methods quantify uncertainty probabilistically, based on analyses of past demographic data and the views of experts. Fertility, mortality and migration are considered as stochastic processes. The parameters of these processes are fitted to match the errors of past forecasts (see Alho *et al.*, 2008). Again, judgment may be used. Thereafter, sample paths for future population by age-groups are simulated. We deal with demographic uncertainty by using such stochastic population projections.

We also pry more information out of stochastic population projections than has been done previously. In essence, we add demographic forecasts for the future that start in different time points in simulated population paths. Given the uncertainty of population forecasting, it might seem that trying to forecast what future population forecasts are like, would be nearly hopeless. We argue, however, that forecasts are, for both theoretical and practical reasons, more regular than actual developments. As a practical reason, it should be mentioned that the development of the recent past often has a heavy influence on projections of the remote future.

Stochastic population projections are produced by a computer program *PEP* (for a description, visit http://www.joensuu.fi/statistics/juha.html). Another computer program *FPATH* extends the application of results from *PEP* to forward-looking OLG models, where agents are allowed to revise their lifetime economic plans as they realize that population has not evolved according to the expected path. For this purpose *FPATH* calculates a numerical approximation to the conditional expectation of future population at future years for a (typically random) *subset of paths* We can think of the conditional expectation as being *a forecast of what would be a forecast* in a future year. This methodology is new, and is described in more detail in Alho (2011) and in Lassila, Valkonen and Alho (2011).

Figure 3 *Population in Finland, as forecasted by Statistics Finland*

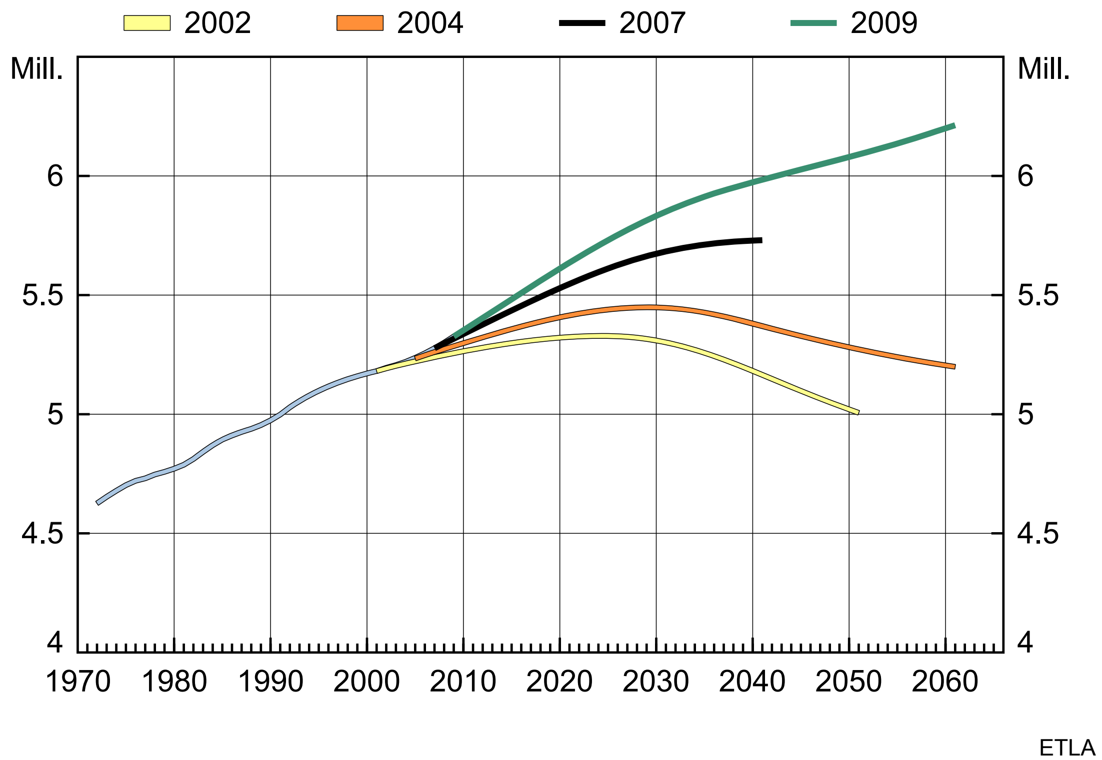
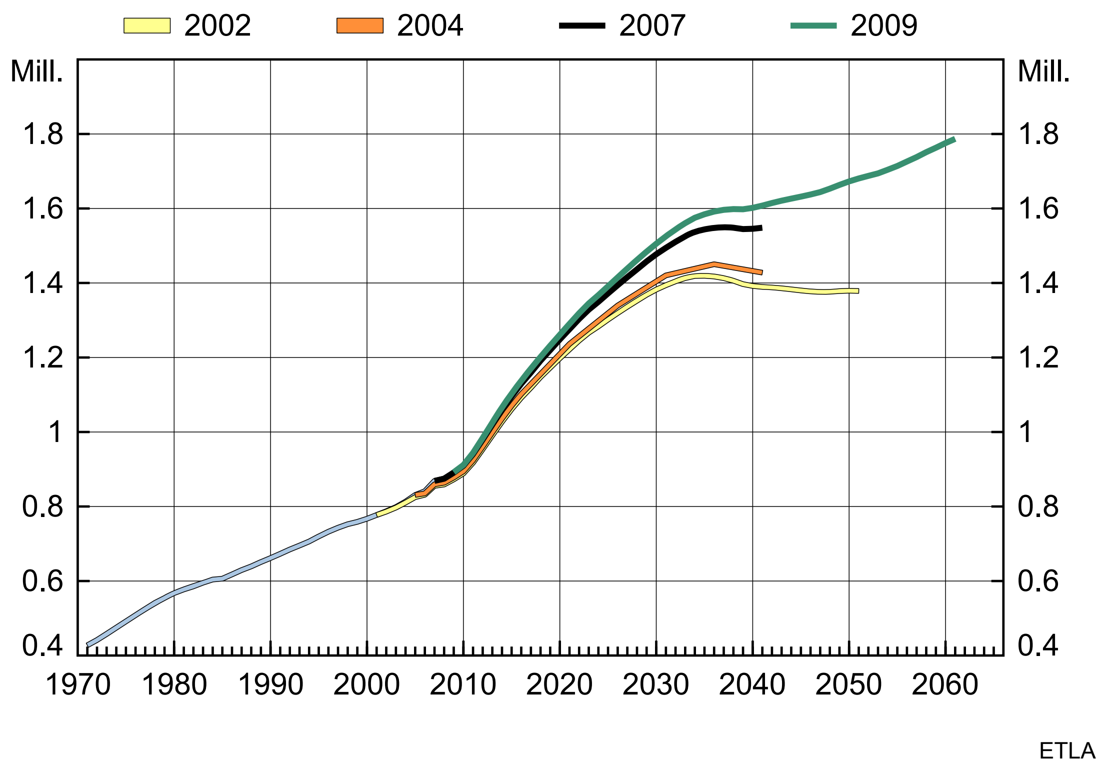


Figure 4 *Population in ages 65+ in Finland, as forecasted by Statistics Finland*



The stochastic projection for population in ages 65+ in Finland is presented in Figure 5. Half of the simulation outcomes are in the shaded area around the median. 10% of the outcomes are above the 90% line and 10% are below the 10% line.

Figure 6 describes population in ages 65+ in one path of the simulated population projections for Finland, produced by the program *PEP*. The solid line is the actual simulated path, and the dotted lines represent the forecasted forecasts for the path. The forecasts lie nicely below the actual path, resembling those in Figure 4. This is not generally true in other simulated paths, where the forecasts can and do both overestimate and underestimate the 'actuals'.

Figure 5. Predictive distribution of population in ages 65+ in Finland

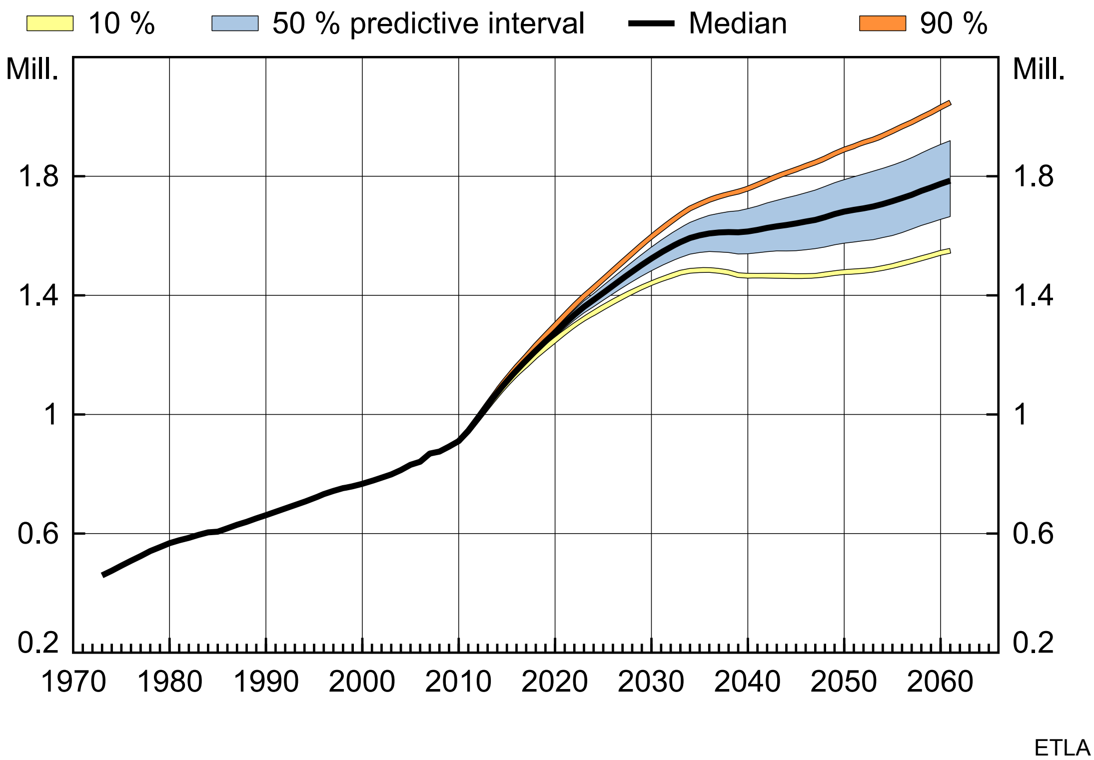
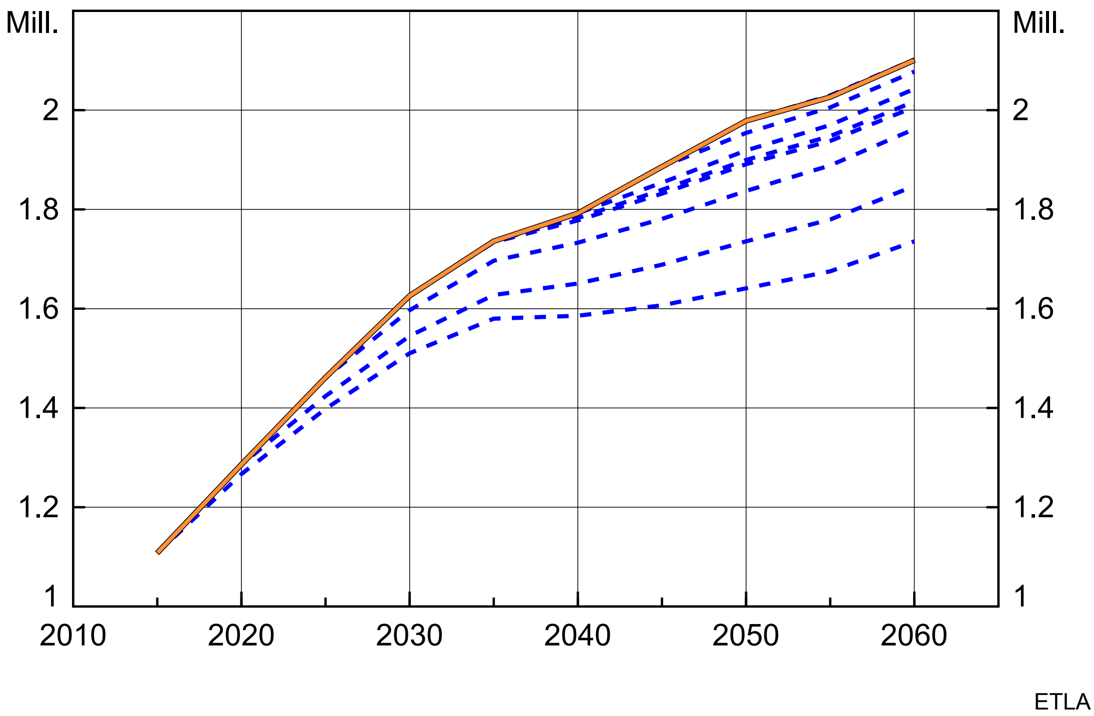


Figure 6. Population in ages 65+ in Finland in one simulated path



5.2.4 Stochastic sustainability analysis

A well-known definition of the sustainability of fiscal policies is the OECD view: "Sustainability is basically about good housekeeping. It is essentially about whether, based on the policy currently on books, a government is headed towards excessive debt accumulation." (Blanchard *et al.* 1990, p. 8). More precisely: "Fiscal policy can be thought of as a set of rules, as well as an inherited level of debt. And a *sustainable fiscal policy* can be defined as a policy such that the ratio of debt to GNP eventually converges back to its initial level" (p. 11).

Forward-looking approaches to sustainability, like the one we apply here, projects future values for the determinants of the debt dynamics and develops measures that quantifies the needed adjustment if unsustainable dynamics is detected. The quality of data and the elabourateness and sophistication of the models used have developed a lot in the past few years, but there is still much room for improvement[47].

[47] "The process of developing long-term budgets is in its infancy, and there is neither a single analytical approach nor a fiscal rule for sustainable development that has achieved agreement as best practice." Ulla (2006).

Our stochastic sustainability analysis can be described by four steps[48]. Firstly, a large number of sample paths of the key variables are produced using stochastic models. Secondly, future public expenditure and taxes associated with each of these paths are simulated using an economic model. Thirdly, the simulation results are described and the probability of sustainability problems is evaluated. Fourthly, alternative policies are formulated, their results are simulated, and the outcomes are evaluated.

Studies that utilize stochastic population projections mainly use accounting models to analyze the sustainability of pension systems (e.g. CBO, 2001 and Auerbach and Lee, 2006). The method of stochastic forecasting has been applied also to the unit costs of health care, see Boards of Trustees (2003). Lassila and Valkonen (2004) analyze how prefunding could smooth the costs of health and LTC in time. The effects of both economic and demographic uncertainty on aggregate public finances are studied in a similar accounting framework by Lee and Tuljapurkar (2001). Alho and Vanne (2006) and Sefton and Weale (2005) used generational accounting to perform a corresponding risk analysis.

Alho *et al.* (2002) and Alho, Jensen, Lassila and Valkonen (2005) were the first to analyze ageing using a large set of OLG model simulations; the application concerned the Lithuanian economy. Fehr and Habermann (2006), Draper *et al.* (2008) and Alho *et al.* (2008) present similar results for some other countries. Lassila and Valkonen (2008) analyze fiscal sustainability of the Finnish public sector using stochastic projections to describe the uncertain future demographic trends and asset yields. They also analyze three policy options aimed at improving sustainability.

5.3 Sustainability of publicly financed health and long-term care

There is a policy baseline that is used in each of the 200 model runs. It is our interpretation of 'the policy currently on books'. In this baseline, welfare transfers and services are provided according to current rules and practices. In case of statutory pensions and expenditures municipalities, the current financing rules are followed. State tax rates are held constant, so variation in expenditure and tax bases causes variation in public debt.

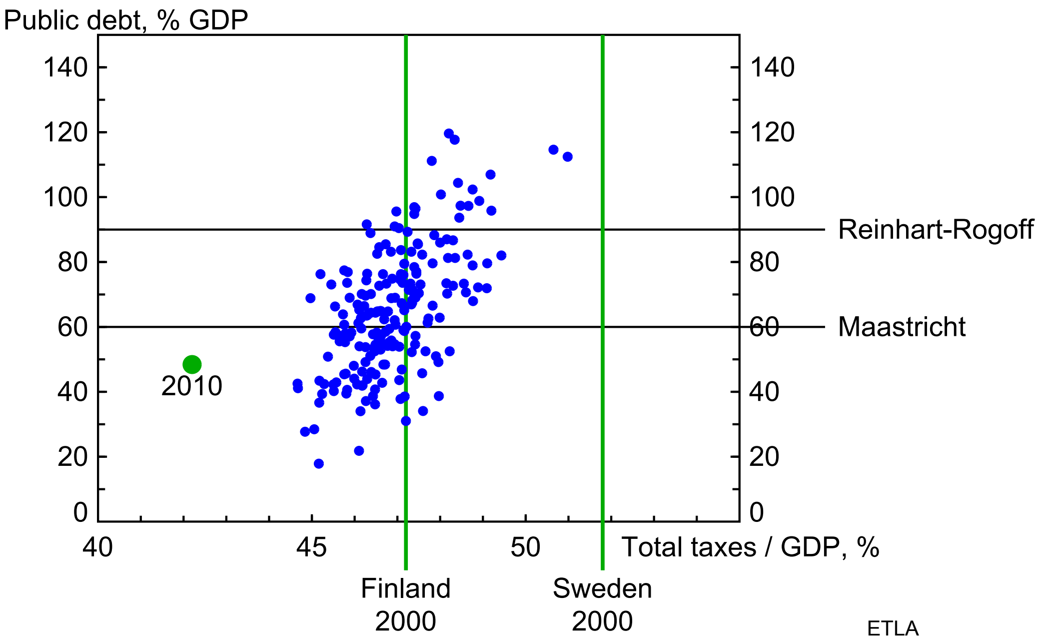
Pension contribution rate adapt to expenditure and to the wage bill, which vary from one demographic path to another. Aggregate health and long-term care

[48] There is also another branch of numerical stochastic sustainability analysis. It analyses the vulnerability of debt to adverse shocks. Sustainability simulations are performed typically for the short or medium term using highly aggregated econometric models (see e.g. Mendoza and Oviedo, 2004).

costs depend on population age structure and proximity to death. They are financed by municipal taxes, which thus also depend on demographic variables. Part of health care and LTC expenditure is, however, financed by state grant to municipalities. The rules of state grants in the model are in line with our advanced projections of the health and long term care expenditure, explained in section 5.2.2. The current rules give too much weight to age structures, and using them in the model would result in a different public debt and municipal tax combination.

We describe the outcomes of this baseline policy first on gross public debt and on a total tax measure, which consists of social security contributions, municipal taxes and all state taxes. Both debt and taxes are related to GDP. Figure 7 describes the outcomes that we can expect this base policy to produce in the 2060s. Each dot represents the situation in one population path. The outcomes are separated only by demographic developments, and the economic reactions of the households and firms to both projected and actualized demographics.

Figure 7 Public debt and taxes in Finland in the 2060s



In an ageing society, it is the nature of this baseline policy that pension contributions and municipal taxes will increase. This increases total taxes in relation to GDP. We do not know by how much, but can make probabilistic statements. As each stochastic population path is equally likely, and thus also the dots in Figure 7 are equally likely, counting the number of dots within given debt and tax ratio limits yields corresponding probabilities. The tax ratio has about one-third chance of exceeding the highest value thus far in Finland, 47.2% in

2000. In all the simulations the tax rate rises markedly but stays below that in Sweden in 2000, 51.8% of GDP, which is the highest rate recorded so far in the EU's tax statistics.

Despite growing total taxes, indebtedness is also likely to increase. State tax rates are held constant, and the increase in state grants to municipalities, due to growth in health care and LTC expenditure, is financed by borrowing. The gross debt/GDP ratio is likely to rise over the Maastricht limit, and with a 10% probability over the 90% level that Reinhart and Rogoff (2010) consider harmful for economic growth. Moreover, such a jump in the debt ratio would represent a huge resource shift from future generations to the current ones.

The baseline demographic projection generates a fairly small sustainability gap, about 2% of GDP.

But certainly the possibility of much bigger problems cannot be ruled out. There is about 30% chance of taxes becoming higher than ever before in Finland and at the same time debt exceeding the Maastricht criterion. Furthermore, there is an 8.5% chance for the very difficult outcome that tax rates are higher than in 2000 and indebtedness exceeds 90%. It is very likely that a radical policy change would take place long before such numbers are realized. In that sense the baseline simulations presented give a probabilistic view of the resilience of the current policy rules to demographic uncertainty.

If total taxes in the society limits social expenditure, then there is a trade-off between pensions on one hand and health and LTC expenditure on the other hand. Thus we cannot evaluate the sustainability of health and LTC financing entirely alone.

Total taxes may not, however, be the most relevant tax measure in assessing the sustainability of health and LTC financing. They are financed to a great extent by municipal taxes, which we assume to rise according to expenditure. The following Figure 8 shows the relationship between the simulated health care and LTC expenditure and the average municipal tax rate in the 2060s. Again, each dot represents different demographic scenario. The positive correlation is easily observable. The unfavorable demographic scenarios generate high expenditure, which compel the municipalities to raise taxes. The highest average municipal tax rates are not likely to occur, since they would mean very high tax rates in the municipalities with the oldest population structure.

There is also a similar positive correlation between the state and municipal finances. This is shown in Figure 9. From the viewpoint of the aggregate sustainability of the public finances this positive correlation reduces the possibilities of risk sharing between the state and municipalities. Note though that although ageing affects the states and municipalities in many similar ways, their quantitative consequences differ. Outlay pressures and tax base effects do differ. When municipal expenditure is high, so is the state's, and in our simulations this leads to high debt. But high debt can occur also without high municipal taxes.

Figure 8 *Health and long-term care expenditure and municipal taxes in the 2060s in Finland*

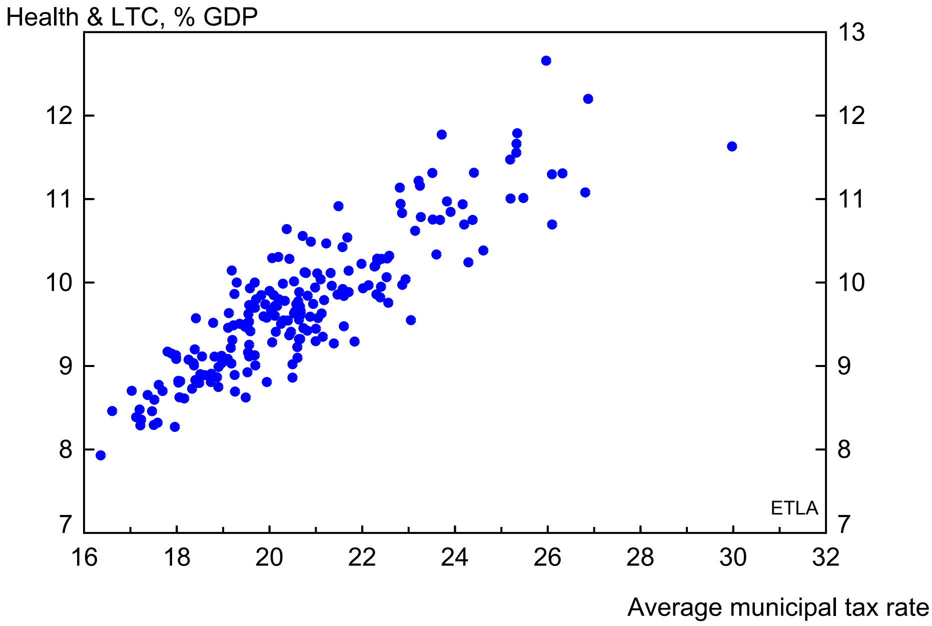
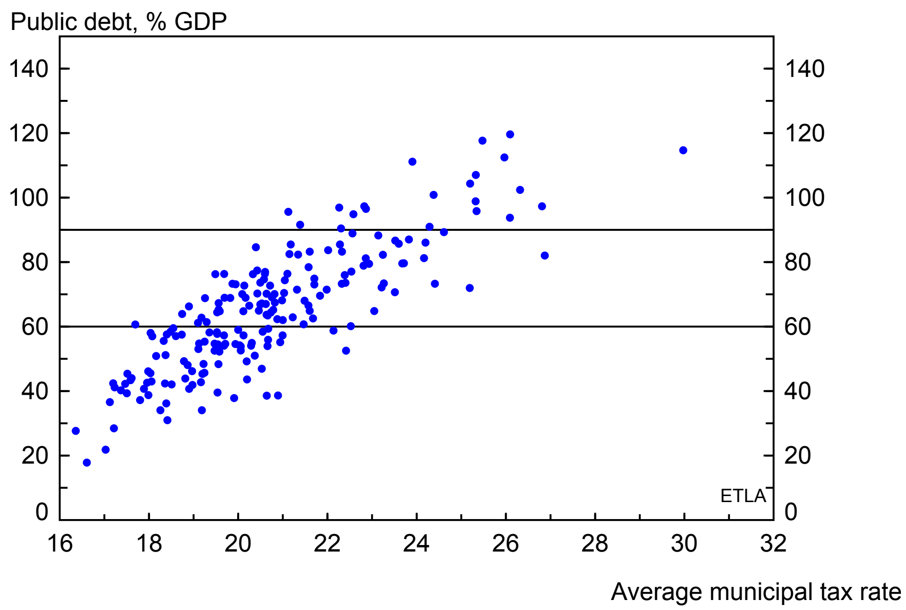


Figure 9 *Public debt and municipal taxes in the 2060s in Finland*



5.4 Sustainability and policy rules

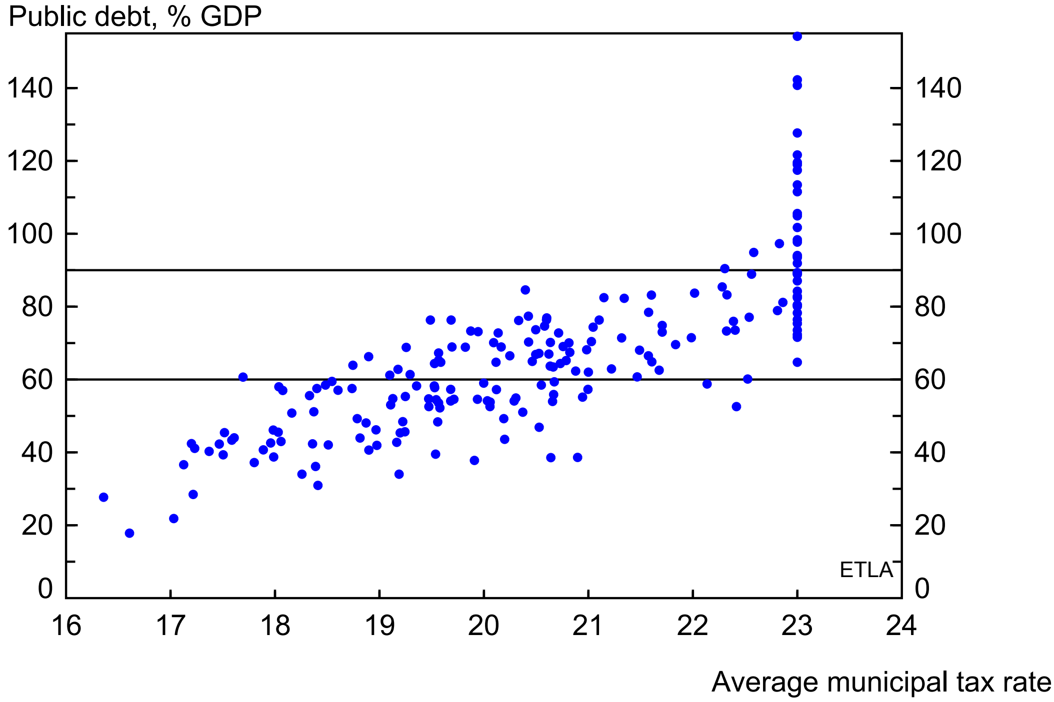
The base policy contains many rules that affect the way public finances adjust to changing demographics. Besides those concerning pension contributions and municipal taxes, there is longevity adjustment of pension benefits, and several indexing rules. Despite these adjustments, it seems from the 2060 outcomes that fiscal policy does not react to expected difficulties in public finances in a sufficient manner. In many empirical sustainability analyses this is the case throughout, as Leeper (2010) criticizes. In our model-based analysis we can go further and study the effects of specific additional policy rules.

Since the baseline is problematic from the point of view of municipalities, the state may consider taking over the responsibility for health and LTC financing. We assume that in such a situation the state finances the whole health and LTC service costs above a certain limit value for the average municipal tax rate. This could happen in practice in the form of e.g. national insurance proposed by Forss (2003). We illustrate this by selecting a limit of 23% for the average municipal tax rate, and call this Policy rule 2 (Rule 1 is the baseline policy; see Table 1). The average for 2010 was about 19%. If the differences in municipal tax rates will stay the same as in 2010, an average of 23% would mean that the top rates would be at least 25% and the lowest rates above 20%.

The 23% limit for municipal taxes is met with close to 20% probability. From Figure 9 it is evident that they are all cases where public debt is problematic in any case. If the state continues to keep tax rates constant, taking more responsibility for health and LTC financing inevitably leads to even higher indebtedness. This is illustrated in Figure 10. As these outcomes must be considered unsustainable, we study alternatives where the state reacts by raising the VAT rate, based on different policy rules or guidelines.

We study two alternatives (Policies 3 and 4 in Table 1) where the state acts on expected average municipal tax rate. The measure is to increase the VAT rate permanently by 2%-points. The question is then, how far decision-makers should look, in order to improve things. We compare a rule where the state looks forward, and bases the VAT decision on the 10-year forecast of the municipal tax rate, to a backward-looking rule where the state acts on the observed municipal tax rate. We show that the debt problems become smaller if the state acts on forecasts than if it acts on observed developments. The improvement is not big, however, and does not remove the threat of a debt problem. A much better result is obtained if the VAT increase is based on expected development of the debt/GDP ratio, instead of the expected average municipal tax rate (Policies 5 and 6 in Table 1).

Figure 10 Public debt and municipal taxes, with ceiling, in the 2060s in Finland



In Table 1 the 200 simulation outcomes in 2060 are divided into several categories. Normal tax rates are those below the Finnish 2000 total tax rate, 47.2% of GDP. High is any tax rate above the normal. Public gross debt, as per cent of GDP, is considered normal if it is below the Maastricht treaty level of 60%. Above that it is high, and if it exceeds the 90% level it is classified as very high. These limits are of course arbitrary but serve a purpose. The debt limits are self-evident; 60% is based on EU policies and 90% is based on an extensive study by Reinhart and Rogoff. The tax rate limit is strictly country-specific.

If one considers the very high debt outcomes as the main threat for sustaining the baseline policy, then we note that compared to the baseline, all other policy rules considered diminish the probability of high indebtedness. Both without and with the municipal tax ceiling, the likelihood of very high debt in the 2060s was slightly above 10%. If the state takes over the health and LTC expenditures above the 23% municipal tax ceiling and increases the VAT rate by 2%-points at the same time, the probability declines to 8%. If the state increases the VAT rate already when anticipating the financing switch, the likelihood declines to 6.5%. These are notable improvements. The probability can, however, be reduced much more if the state's VAT decision is based on the public debt/GDP criterion instead of the municipal tax rule. And also with the debt criterion it is better to use a forward-looking than a backward-looking rule.

Table 1 *Base policy and policy rule outcomes in 2060 (share of cases in different debt-tax categories,%)*

	(Policy 1) Baseline	(Policy 2) Baseline with 23% ceiling for average municipal tax	(Policy 3) Policy (2) + VAT increased when average municipal tax at ceiling	(Policy 4) Policy (2) + VAT increased when average municipal tax forecast to exceed 23% within 10 years	(Policy 5) Policy (2) + VAT increased when debt/GDP ratio exceeds 60%	(Policy 6) Policy (2) + VAT increased when debt/GDP ratio forecast to exceed 60% within 10 years
Normal debt and normal taxes	37,5	37,5	37,5	37,5	48,0	53,5
Normal debt and high taxes	5, 0	5,0	5,0	6,5	18,5	25,5
Normal debt, total	42,5	42,5	42,5	44,0	66,5	79,0
High debt and normal taxes	26,0	26,0	26,0	24,5	9,0	3,0
High debt and high taxes	21,0	20,5	23,5	25,0	19,5	14,5
High debt, total	47,0	46,5	49,5	49,5	28,5	17,5
Very high debt and normal taxes	2,0	3,0	1,5	1,0	1,0	0,5
Very high debt and high taxes	8,5	8,0	6,5	5,5	4,0	3,0
Very high debt, total	10,5	11,0	8,0	6,5	5,0	3,5
Normal taxes, total	65,5	66,5	65,0	63,0	58,0	57,0
High taxes, total	34,5	33,5	35,0	37,0	42,0	3,0

Increasing the VAT rate means increasing the total tax burden in the economy. Still the debt-based policies, (5) and (6) in Table 1, increase the probability of outcomes within the ‘normal debt and normal taxes’ area. They do increase the tax rate but not enough to exceed the Finnish record in 2000. Figures 11 and 12 compare the most effective policy (6) with baseline amended with the municipal tax ceiling.

Figure 11 Frequency distribution of public debt, as% of GDP, in the 2060s

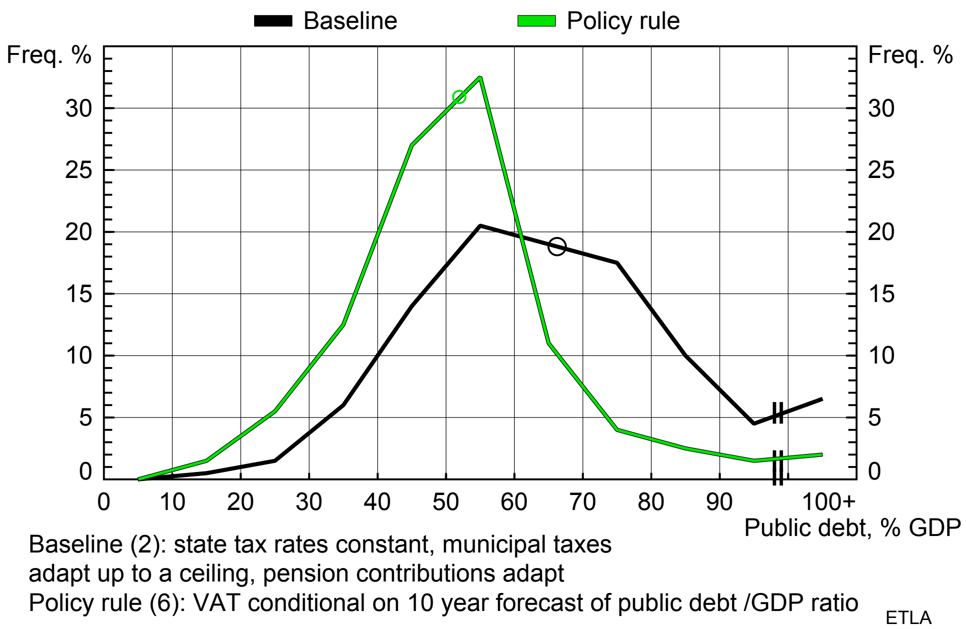


Figure 12 Frequency distribution of total taxes, as% of GDP, in the 2060s

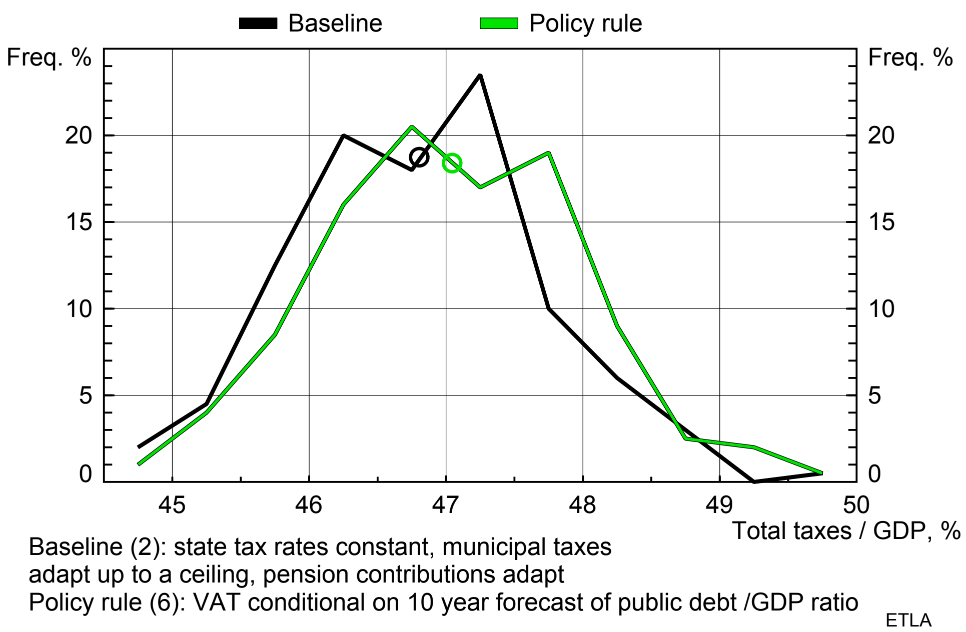


Figure 11 confirms the view that forward-looking tax policy can effectively reduce the threat of future debt problems. Figure 12 shows that taxes in total increase because of this policy, but not very much. The expected value of total taxes/GDP, marked with a circle in the figure, increases by about half a per cent.

5.5 Summary and conclusions

Analysing fiscal sustainability and calculating sustainability gaps relies heavily on demographic projections. These projections are changed at regular or irregular intervals. These changes are not always minor – in fact they are often large. In this paper we have analysed what implications these inevitable changes have for sustainability analysis and for policy conclusions.

We have specifically focused on the fiscal pressures that financing health and long-term care (LTC) with municipal taxes, with help from state aid, will bring about in ageing Finland. We ask whether this financing system is sustainable in the specific sense that citizens can rely on receiving the services in the future. As future is inevitably uncertain, no definite answer can be given. We can, however, quantify some uncertainties and illustrate and evaluate their effects. We can form a probabilistic view of the public debt and taxation developments that financing health and LTC will cause. This view then serves as a basis for our evaluation of the sustainability of the system, or, phrased differently, of the credibility of the promise concerning publicly financed health and LTC services in the future.

We chose the time span so that it should suffice for those who are about to leave the labour market. If one is 50, then the horizon should be at least 50 years, for living up to 100 years will not be rare. If a 50-year old does not think that promises concerning future welfare services are fully credible, she or he still has 10 – 20 years to take individual precautionary measures while being part of the labour force.

General assessment of sustainability

Even with our assumptions of future health and LTC demand, which are low compared to those used in other fiscal projections made for Finland, difficulties in sustainability loom large.

In our baseline policy, municipal taxes adjust to health and LTC expenditures and changes in the tax base, and pension contributions adjust to pension outlays. In an ageing society, it is the nature of this baseline policy that taxes will increase. The total tax/GDP ratio has about one-third chance of exceeding the highest value thus far in Finland, 47.2% in 2000. In all simulations the tax rate stays below that in Sweden in 2000, 51.8% of GDP, which is the highest rate recorded in EU’s tax statistics.

Despite growing tax rates, indebtedness is also likely to increase. The debt ratio is likely to rise over the Maastricht limit, and with a 10% probability over the 90% level that Reinhart and Rogoff (2010) consider harmful for economic growth.

Whether this policy line would be sustainable or not, is a matter of opinion. Some may find most of the outcomes generally plausible, others not. But as future users of these welfare services we are not satisfied with the outlook. The possibility of problems is too high. There is about 30% chance of taxes becoming higher than ever before in Finland and at the same time debt exceeding the Maastricht criterion. Furthermore, there is an 8.5% chance for the very difficult outcome that tax rates are higher than in 2000 and indebtedness exceeds 90%. We think that the likelihood of cuts in health and LTC services in the future is too high with the baseline policy, and thus some amendments or alternatives should be considered.

Note also that if total taxation in the society limits social expenditure, then there is a trade-off between pensions on one hand and health and LTC expenditure on the other hand. Thus we cannot evaluate the sustainability of health and LTC financing entirely separately. If pension financing would be solved in a similar way to that in Sweden, with a fixed contribution level, then this problem would disappear.

Municipal aspect

An additional and independent sustainability risk comes from the municipal sector. If the average tax rate rises to a high level, it is very likely that some small municipalities would need to raise their taxes to a level that would not be acceptable in practice. The state would need to step in. We assume here that in such a situation the state finances the whole health and LTC service costs above a certain limit value for the average municipal tax rate. We illustrate this by selecting a limit of 23% for the average municipal tax rate. The average for 2010 was about 19%. If the differences in municipal tax rates will stay the same as in 2010, an average of 23% would mean that the top rates would be at least 25% and the lowest rates above 20%.

Whether municipal taxes reach the limit, depends on the demographic developments in the future. In our simulations this happens in almost 20% of the cases. But if that happens, the state is already indebted. In all baseline simulations where the average municipal tax rate exceeds 23%, the public debt exceeds 60% of GDP. Even if the state would increase its own tax rates to cover the financing task that exceeds the limit, the debt problem is bound to be large. The standard of services would no doubt be under threat.

Can the state do better? Yes. It can prepare in advance. We first study alternatives where the state acts on expected average municipal tax rate. The action is a permanent increase in the VAT rate. The question is then, how far should the decision-makers look, in order to improve things. We show that the likelihood of future debt problems become much smaller if the state has a 10-year horizon than if it acts on observed developments.

Secondly, we study policies where the VAT rise is conditioned on the public debt situation instead of municipal taxes. These policies turn out to be more effective. And again, a 10-year horizon ahead is better than a backward-looking rule. Although demographic forecasts are erroneous, they appear to contain enough information to be useful in policy design.

Policy lessons

We have shown that any sustainability measure is uncertain, and that the uncertainty is large. This is in accord with previous studies, and by itself bound to make policy considerations difficult. The good point is, we can give quantitative assessment of the uncertainty and illustrate the various outcomes of the base policy.

Although the magnitudes of ageing are uncertain, and forecast errors probably large, ageing policies must respond in advance. Uncertainty should not imply inaction. Inaction is a policy choice, and here a rather poor one. Our simulations show that forecasts contain information and can be used in policy design.

There should be a plan for worse than expected future developments. Actions can include postponed conditional measures. They should form a coherent program, with well-defined thresholds. They should also be credible. The credibility requirement may be difficult to operationalize, but as long as the situation is good or looks good, relying on future actions may be a viable option.

There is not much point in arguing about the exact size of the sustainability gap. The question is whether the policy currently on books is sustainable in the foreseeable future with a reasonable probability. Relying on expected developments, with a 50% probability, is not reasonable. It is a gamble, like tossing a coin. Heads, and you'll get the services at least as promised, tails, and you'll get less? Certainty is not achievable, but the risk can be reduced.

Any alternative policy outcome is also uncertain. But we can again describe and illustrate them. This hopefully helps us to think of possible ways that problems and difficulties may arise.

The policy rule analysis could have been used to derive also the welfare effects of different policy choices in addressing sustainability problems. This could be especially useful when considering postponing decisions. Their costs, and whom they occur to, can be illustrated, thus avoiding one of the critical faults in using unsustainable paths described in Leeper (2010). We consider such work a necessary ingredient in future analysis.

Methodological lessons

We have amended stochastic population projections with embedded and gradually updated demographic forecasts. At each time-point on each population path considered there is also a simulated demographic forecast for the future. The agents in the economic model make their future plans based on this demographic forecast that prevails there and then. A new demographic forecast is made when the economy moves to the next period, and agents update their plans. Technically the tree-like combination of stochastic population projections with embedded demographic forecasts is obtained by joint use of computer programs *FPATH* and *PEP*. The ranges of forecast revisions seem quite relevant, when compared to the adjustments in demographic forecasts by Statistics Finland between 2002 and 2009.

Using periodically updated population projections as an input in a forward-looking economic model produces results that, we think, have strong links to decisions that are considered or actually made in the real world. Each update in the official population projections changes our conception of the future. All public policies and private behaviour contingent to the conception of the future are subject to change.

Introducing forecasts embedded in stochastic population projections allows us to analyze policies that are based on forecasts. There is an obvious way forward here. Analyze all relevant policy rules, and compare results. This is very tedious, and difficult. There are many parameters that could be changed and should be analyzed. In our rather simple policy rules such parameters are the threshold values and length of the period they are calculated from, and other specifications related to them. The size of the triggered policy measures should also be studied. For pedagogical purposes, rough examples may suffice. For quantitative policy guidelines, much more work is needed.

This type of analysis produces a vast amount of simulation results – so vast that choosing what to present is an essential part of any study. The economic model output consists of stylized national accounts for each period, added by household behavior by 5-year birth cohorts, three educational groups and a maximum age of 100 years. 50 years with a 5-year unit period and a 50-year horizon of forecasts means that the baseline consists of 100 national accounts for each of the 200 population paths used, in total 20,000 national accounts.

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